Illinois U. Library

ILLINOIS TECHNOGRAPH

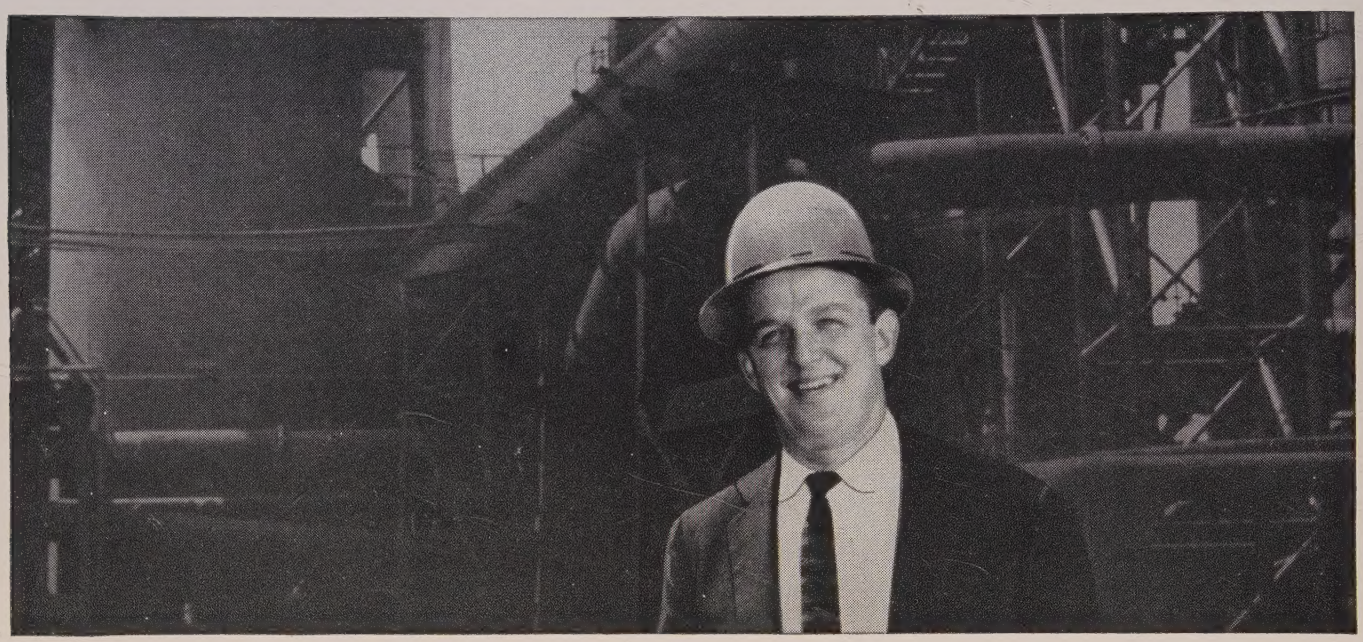
NBS — THE NATION'S STANDARD

THE SUEZ CANAL

DECEMBER, 1956 .25

Thomas A. Beattie, class of '47,
speaks from experience when he says:

"At U. S. Steel one has a great amount of varied experiences. There is truly never a dull moment."



After receiving his B.S. in Mechanical Engineering in 1947, Mr. Beattie entered the employ of U. S. Steel as a student engineer. That was on September 22, 1947, and included service in the United States Navy from 1943 to 1946.

Mr. Beattie's progress from that date onward is typical of that of many engineering graduates who plan their future with U. S. Steel. For, within two years, we find Mr. Beattie advanced to the position of Process Engineer, Maintenance Department. Then on April 16, 1951, he was promoted to Relief Foreman, Shops, Maintenance Department. On March 1, 1952, he was made Turn Foreman, Blooming and Bar Mills, Mechanical Maintenance Department. And on January 1, 1955, he was promoted to his present post of Assistant Superintendent, Maintenance Department, of U. S. Steel's National Tube Division's National Works.

In this position, Mr. Beattie's responsibilities are numerous. They include the Service Power House and Skelp Mill area; maintenance of four blast furnaces and blast furnace auxiliaries, plus a sintering plant; maintenance of two blooming mills and soaking pits; maintenance of one bar mill; maintenance of three Bessemer converters, three open hearth furnaces, three open hearth auxiliaries, and seventy overhead cranes ranging from two to 200 tons. He supervises 680 men.

As Mr. Beattie remarks: "A steel plant includes all departments . . . every craft known to industry. In the space of three years, a U. S. Steel engineer can obtain experience that may take three times as long under different employment circumstances. One meets all types of problems and personnel. Each day is varied, certainly not dull, and yet no problem is insurmountable. Certainly, there is no possibility of getting 'into a rut' here."

Should you be interested in a challenging and rewarding career with United States Steel and feel that you can qualify, consult your college placement director for further information. Upon request, we shall be glad to send you a copy of our informative booklet, "Paths of Opportunity." Simply write to United States Steel Corporation, Personnel Division, Room 1662, 525 William Penn Place, Pittsburgh 30, Pa.

USS TRADE MARK

UNITED STATES STEEL

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

AMERICAN BRIDGE • AMERICAN STEEL & WIRE and CYCLONE FENCE • COLUMBIA-GENEVA STEEL • CONSOLIDATED WESTERN STEEL • GERRARD STEEL STRAPPING • NATIONAL TUBE
OIL WELL SUPPLY • TENNESSEE COAL & IRON • UNITED STATES STEEL PRODUCTS • UNITED STATES STEEL SUPPLY • *Divisions of* **UNITED STATES STEEL CORPORATION, PITTSBURGH**
UNITED STATES STEEL HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY

Editorial Staff

Editor
Harry Hirsch

Photo Editors
David L. Komyathy
Jack Siebert

Assistants
James Kries
Jon Grushka
Rick Van Weelden
Don Snedeker
John Brennan
Glenn B. Andrews
Dotty Hazel
Roger L. Harrison
Phil Hicks
Frank Hunyady
Mike Coleman
Dale Mackowiak
Carole Kavanagh

Business Staff

Business Manager
Don Georgi

Circulation Director
Phil Philhower

Faculty Advisers

R. W. Bohl
P. K. Hudson
O. Livermore

MEMBERS OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman: Prof. R. W. Bohl, University of Illinois, Urbana, Ill.

Arkansas Engineer, Cincinnati Cooperative Engineer, City College Vector, Colorado Engineer, Cornell Engineer, Denver Engineer, Dreel Technical Journal, Georgia Tech Engineer, Illinois Technograph, Iowa Engineer, Iowa Transit, Kansas Engineer, Kansas State Engineer, Kentucky Engineer, Louisiana State University Engineer, Louisiana Tech Engineer, Manhattan Engineer, Marquette Engineer, Michigan Technic, Minnesota Technolog, Missouri Shamrock, Nebraska Blueprint, New York University Quadrangle, North Dakota Engineer, Northwestern Engineer, Notre Dame Technical Review, Ohio State Engineer, Oklahoma State Engineer, Oregon State Technical Triangle, Pittsburgh Skyscraper, Purdue Engineer, RPI Engineer, Rochester Indicator, SC Engineer, Rose Technic, Southern Engineer, Spartan Engineer, WSC Technometer, Wayne Engineer, and Wisconsin Engineer.

Published eight times during the year (October, November, December, January, February, March, April and May) by the Illini Publishing Company. Entered as second class matter, October 30, 1920, at the post office at Urbana, Illinois, under the Act of March 3, 1879. Office 215 Civil Engineering Hall, Urbana, Illinois. Subscriptions $1.50 per year. Single copy 25 cents.
Reprint rights reserved by *The Illinois Technograph*.
Publisher's Representative—Littell Murray-Barnhill, 369 Lexington Avenue, Chicago 11, Ill. 101 Park Avenue, New York 17, New York.

THE ILLINOIS TECHNOGRAPH

Volume 72 Number 3

Contents:

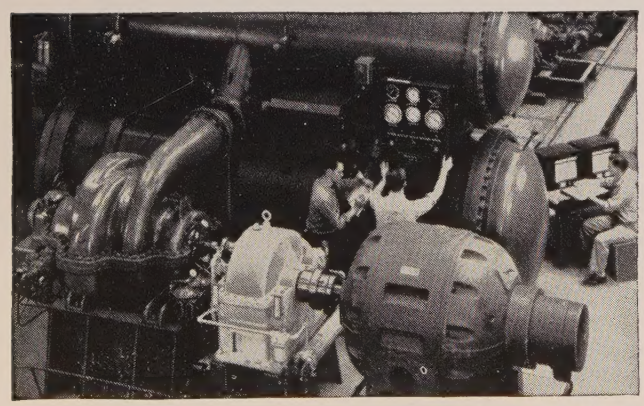
Editorial ---- 9
Our Nation's Yardstick ---- 13
Suez Canal ---- 21
Steinmetz ---- 30
Bugatti Royale ---- 37
Technocutie ---- 42
VTOL Aircraft ---- 48
Campus Personality ---- 53
Short Story ---- 58
Launching the Satellite ---- 61
Brainteasers ---- 66
Co-Op Plan ---- 69
Society Column ---- 72
Skimming ---- 77
Engineer Dating Guide ---- 84
Technoclips ---- 88

Our cover and frontispiece

This month's cover shows an aerial view of National Bureau of Standards headquarters in Washington, D.C., while our frontispiece illustrates NBS' 10-million-pound compression machine which aids stress analysis of full-scale structures. (All photos courtesy of National Bureau of Standards)

"POWER OFF!" Test operations are directed from this central control room, where special measuring instruments greatly speed up the collection of pump performance data. That's one way Worthington products are made more reliable by using . . .

. . . the world's most versatile hydraulic proving ground



COMPREHENSIVE TESTS are run on a Worthington centrifugal refrigeration unit (lower left) now in service as one of the Arabian American Oil Company's central air conditioning units in Dhahran, Saudi Arabia.

When you make pumping equipment that has to stand up and deliver year after year anywhere in the world, you've got to be sure it will perform as specified.

That's why we built one of the world's largest hydraulic test stands at our plant in Harrison, New Jersey. Here, over a half-acre "lake," we can check the performance of anything from a fractional horsepower unit to pumps handling over 100,000 gallons a minute. When you realize there are thousands of sizes and types of centrifugal pumps alone, you get an idea of the versatility we had to build into our proving-ground.

Naturally, our new test equipment is a big help to our research engineers, as well as our customers. Now they get performance data on products quickly and accurately. Using it, we can save months, even years, in developing new Worthington fluid and air-handling devices — equipment for which this company has been famous for over a century. For the complete story of how you can fit into the Worthington picture, write F. F. Thompson, Mgr., Personnel & Training, Worthington Corporation, Harrison, N. J.

4.25A

See the Worthington representative when he visits your campus

See the Worthington Corporation exhibit in New York City. A lively, informative display of product developments for industry, business and the home. Park Avenue and 40th Street.

WORTHINGTON

When you're thinking of a good job—think high—think Worthington

AIR CONDITIONING AND REFRIGERATION • COMPRESSORS • CONSTRUCTION EQUIPMENT • ENGINES • DEAERATORS • INDUSTRIAL MIXERS
LIQUID METERS • MECHANICAL POWER TRANSMISSION • PUMPS • STEAM CONDENSERS • STEAM-JET EJECTORS • STEAM TURBINES • WELDING POSITIONERS

Look Us Over . . .

Look over this magazine carefully. We've tried to make it worthwhile reading, with several articles we think will be of interest to you technically, historically or just as a means to pass the time. We've even included a small short story for your pleasure.

Then there are the departments such as the Society Column and an expanded Skimming the Industrial Headlines section. We have dropped our Technocracks section and added Technoclips which features informal comments on each issue.

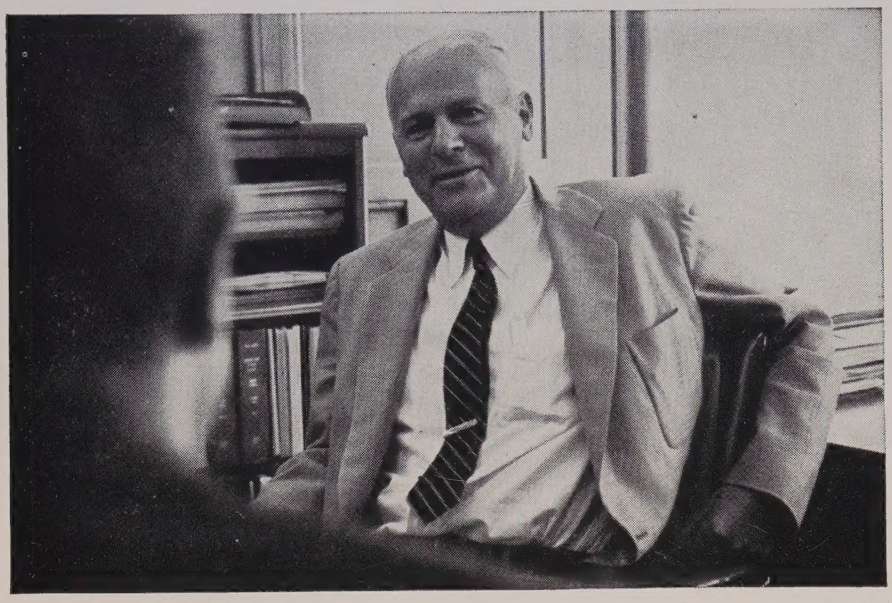
All this is our way of making TECHNOGRAPH better and more widely read, for we think it is one of the best of the college engineering magazines.

If however, you think we have missed something, let us know. If you have a gripe, let us know. If you have an idea you want us to write about, if you want an article about some personality, some industry, some branch of engineering or some technological development, let us know.

A handy form appears on the last page of the magazine at the end of the Technoclips. Clip it out, fill it out and mail to us. We'll be glad to hear what our readers have to say about us.

—H. H.

CAREERS WITH BECHTEL



JAMES F. DEL CURO, *Mechanical Engineer, Power Division*

MECHANICAL ENGINEERING

One of a series of interviews in which Bechtel Corporation executives discuss career opportunities for college men.

QUESTION: *As I understand it, Mr. Del Curo, the Power Division is concerned with the engineering phases of steam-electric generating plants?*

DEL CURO: That's true. Our own department is specifically concerned with the mechanical engineering phases of such plants.

QUESTION: *When the engineering graduate joins your department are his starting duties standard?*

DEL CURO: Yes. The routines are pretty well defined. We know a man learns best by actual doing, so he is put to work immediately on heat balances, line size calculations, specifications, miscellaneous and minor auxiliary equipment, instrument data sheets and information for plant data books.

QUESTION: *In other words, you sort of throw the man in and he has to learn to swim by himself?*

DEL CURO: No. He has plenty of help. He works under the direct supervision of a job engineer or the mechanical group supervisor.

QUESTION: *How long does this training phase last?*

DEL CURO: That will vary with the man, since aptitudes and desires to learn are different. The average is somewhere between a year and eighteen months.

QUESTION: *During this period he will gradually advance to more complicated equipment?*

DEL CURO: Yes. For example, after a while he will be doing original work on heat balances and system studies. He will be able to take an entire "piece" of a project and handle it on his own responsibility. He will become involved with bigger equipment and with the overall aspects of the power plant. Somewhere along the line he will likely be assigned to try his hand at piping materials, piping specifications and combined control specifications.

QUESTION: *What about the man who wants to specialize?*

DEL CURO: If, for example, a man shows a particular interest in steam turbines, instrumentation or control, and demonstrates a special aptitude for one of them, he will often be called on to work on that specialty, without being confined to it exclusively. Thus we encourage specialization, even during the training period, but also make sure that the young man gets overall experience through work in all phases of mechanical engineering.

QUESTION: *What about field experience?*

DEL CURO: That is, of course, highly desirable from his standpoint and ours. We make every effort to assign the young engineer to field work as soon as possible.

QUESTION: *What will he do in the field?*

DEL CURO: When we are building a power plant we try to get the young engineer on the job five or six months before the scheduled start up of the plant. He will actually help the chief start up engineer by writing up procedures, planning the hydraulic washing to steam lines, working on the start up of each piece of the equipment, checking out controls, etc.

He will also handle paper work such as filling out the data sheets that are later turned over to the plant operators to aid them in running the plant. By the time the turbine is rolled and the job ends, the young engineer has been able to see the end result of all the engineering work he and others have done back in the office.

QUESTION: *Are there any other types of field assignments?*

DEL CURO: If the young engineer desires such experience, he is sometimes used in the construction department if that group is shorthanded.

Bechtel Corporation (and its Bechtel foreign subsidiaries) designs, engineers and constructs petroleum refineries, petrochemical and chemical plants; thermal, hydro and nuclear electric generating plants; pipelines for oil and natural gas transmission. Its large and diversified engineering organization offers opportunities for careers in many branches and specialties of engineering—Mechanical... Electrical... Structural... Chemical... Hydraulic.

Write for new brochures showing the wide variety of projects Bechtel builds throughout the world.

Address: John F. O'Connell,
Vice President, Industrial Relations
220 Bush Street, San Francisco 4, Calif.

BECHTEL

BECHTEL CORPORATION

SAN FRANCISCO
Los Angeles • New York • Houston

National Bureau of Standards

OUR NATION'S YARDSTICK

by Jim Kries, Eng. Physics, '59

"I often say . . . that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the state of Science, whatever the matter may be."

—Lord Kelvin
1883

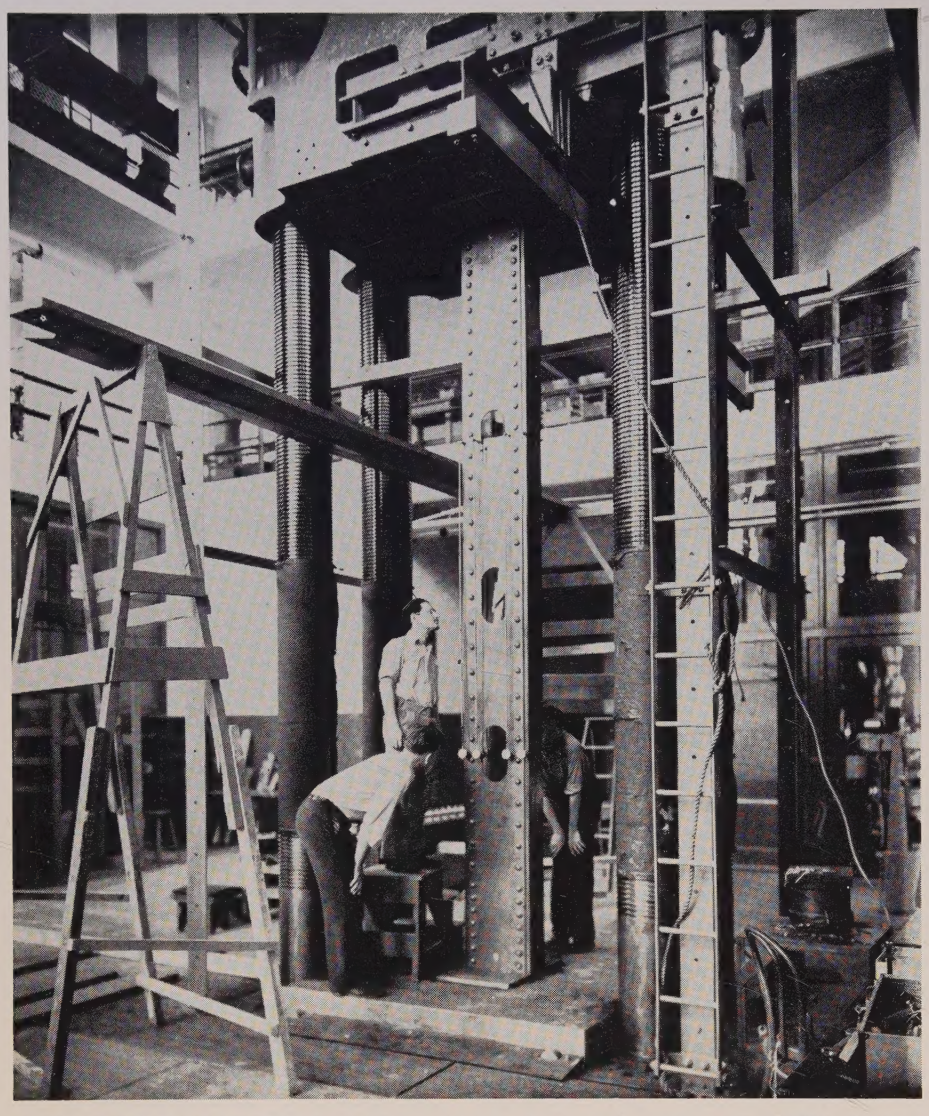
This year, the United States is busily preparing for an active part in the proceedings of the International Geophysical Year. All of this might never have been. Little more than fifty years ago, at the turn of the century, American scientific and industrial progress was seriously curtailed by the lack of standard weights and measures. In setting up our new nation, our founding fathers were only interested in setting up standards of weights and measures insofar as they were necessary for standardizing interstate commerce. Their only standardization legislation was aimed at assuring that a bushel of potatoes in Massachusetts would be the same as a bushel of potatoes in Virginia, but the early Congresses were reluctant to regulate commerce even to this extent. Fostered by the Treasury Dept., the Government established standards of weights and measures in 1836. These were narrow in scope and even by 1900, only $10,400 were required to maintain these standards, calibrate surveyor's measures, and carry on other similar activities. The Navy, for example, had to send all of its scientific instruments to Germany for calibration because of our inadequate facilities.

In 1900, the Secretary of the Treasury, Lyman J. Gage, recommended that the government set up a bureau to provide standards of weights and measures to fulfill the needs of American science. This proposal was backed by most of the leading scientists and scientific institutions of that time including George Westinghouse, the Pittsburgh inventor, Wolcott Gibbs, president of the National Academy of Sciences, the American Chemical Society, the American Physics Society, the American Institute of Electrical Engineers, and a large number of governmental agencies.

Congress was impressed, but somewhat hesitant. Many of them realized the need for a standardizing bureau, but were upset by the astronomical expense involved—at least $250,000 (the bureau is now spending $50 million a year). After much discussion, the bill establishing the National Bureau of Standards was passed on March 2, 1901. The bill specified the duties of the bureau as:

". . . that the functions of the bureau shall consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the so-

A PORTION OF THE NBS data processing laboratory showing SEAC, the bureau's high-speed electronic digital computer.



A VIEW OF ONE SECTION of the materials testing department of NBS showing a device for measure tensile and compressive strengths.

lution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere."

It took possession of the nation's only standards: length (two scratches on a platinum-iridium bar one meter apart) and mass (a one kilogram platinum-iridium cylinder). Today there are more than 40 different kinds of scientific standards, and the standards themselves total at least 700. The first duty of the bureau was to establish a set of working standards.

The electrical standards are one example of the many different types of working standards the bureau had to set up. The ampere was simply defined by the rate of deposition of silver, the ohm as the resistance of a specified column of mercury, and the volt as a specified fraction of the electromotive force (emf) of a certain type of standard cell. But preparing such standards, accurately, proved to be a Herculean task. Finally, in 1910, representatives of France, England, and Germany came to Washington, bringing with them their standard cells and standard resistors. The long arduous task of intercomparing the various standards were finally completed and the standards of each country were established in terms of newly defined international units.

Further problems developed. By 1925, the slow drift over time had resulted in serious discrepancies between the standards of the various nations. By international agreement it was decided to re-establish the electrical standards in terms of the three fundamental standards of length, mass, and time. Through the use of such devices as the current balance, a type of beam balance wherein the gravitational force on a one kilogram mass is balanced by the force on coils carrying one ampere, all of the fundamental electrical standards were finally established.

Additional Bureau Functions

Soon after its establishment, the bureau began receiving requests from other government agencies and from industry to perform added services. Most of these were performed under the "solution of problems" clause, but beginning with fiscal year 1910, specific allocations were being made for very specific projects or areas of research. Some of these were: 1910—gaslight standards; 1911—effects of electric currents on pipes and reinforced foundations, testing structural materials; 1913—fire resisting properties of building materials, physical constants of refrigeration materials; 1914—safety in transmission of high potential electricity, testing railroad track measurements and other scales.

It was 1914 when the efforts of the NBS resulted in the discovery of one of the largest shortages in history. The bureau had constructed two "ghost" railway cars, i.e. cars whose weight was accurately known, to check railway scales throughout the country. In the course of their checking, they encountered one that was off by 20,000 pounds—10 tons! This is typical of the way the bureau has endeavored to standardize the measurements of commerce to protect the public.

The Roosevelt economic policies of "belt-tightening" on governmental activity caused such a drop of appropriations for the bureau (from $2 million to $1½ million) that one third of the personnel had to be released and many of the projects were either dropped entirely or severely curtailed. The National Screw-Thread Commission, established in 1918, was one of the projects dropped as a "ridiculous government activity" even though it carried no appropriation. Although screw-threads appeared ridiculous to the 1933 Congressmen, they are of real importance to the nation and the world. It has been estimated that $100 million would have been saved in World War II if there had been agreement between English and American thread standards so as to make their equipment interchangeable. The commission was later re-established "quietly" and has since resulted in the 1948 screw-thread standards agreement between the United States, Canada, and the United Kingdom.

By 1935, the Roosevelt administration and the Congress were beginning to appreciate the immense potentialities of the bureau and started passing appriations for many jobs not specified in the original legislation. Some of these are: standardization of colors and gauges; development of standard testing procedures for sugars, mechanical appliances and equipment; investigation of clay products, textiles, high tempera-

tures, automotive engines, dental materials, and radioactive substances and X-rays, and research in metallurgy, hydraulics and (in cooperation with the industries) industrial development.

Nuclear investigations were started in 1939 when President Roosevelt appointed Dr. Lyman J. Briggs, then director, as chairman of a committee to investigate uranium fission in warfare. The results are just a matter of record. The atomic and hydrogen bombs are all products of this committee's activities. Although the actual contributions of the bureau were too numerous to mention, a few examples might serve to illustrate their specific endeavors.

Like many other elements some distance from the noble metals on the chemical activity chart, uranium ore in the natural state is combined with many impurities. If allowed to remain, these impurities would capture many neutrons and make the *critical mass* prohibitively large and costly. Using a very unusual property of uranium nitrate, that is very soluble in either, bureau scientists were able to produce uranium of high purity in large quantities.

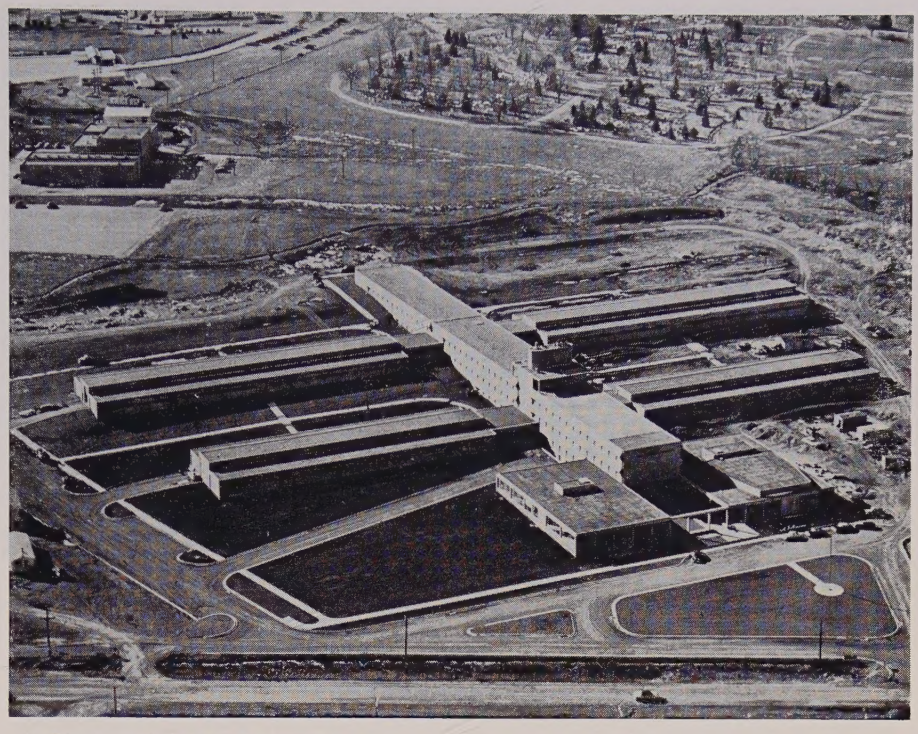
Graphite, used in nuclear control rods for atomic piles, was also proving troublesome. Boron, the plague of many chemical compounds, was present in the graphite rods and was preventing the formation of a chain reaction. Bureau scientists patiently checked each step in the manufacture of the graphite bars with a spectroscope and were finally successful in isolating the offending element.

Another great contribution to the war effort was the bureau's development of the proximity fuze. The first successful radio proximity fuze in the world, developed by bureau scientists, was tested at the Navy's Dahlgren Proving Grounds on February 12, 1941, a short two months after undertaking the project. This fuze, measuring approximately two feet long and about four inches in diameter, and its miniaturized successors was considered to be the second-greatest scientific achievement of World War II (the A-bomb was the first).

Physical Constants Research

The last few years have been busy ones for the bureau. New developments in science and industry have demanded more exact values of physical constants (e.g., "g", the acceleration due to the force of gravity; the velocity of light in a vacuum, etc.), more exact measurement of the fundamental units of length, mass, and time, and the development of new standards as needed (especially radioactivity standards).

The traditional length standard, two scratches on a platinum-iridium bar, is becoming obsolete since even the finite thickness of the scratch marks is becoming intolerable. A new, more accurate length standard has been developed by bureau scientists. It was found that an electrodeless lamp made of mercury 198, an isotope containing two less than the usual number of neutrons, gives off a highly accurate number of fringe rings (exactly 1,831,249-.21) to the meter) when excited by a radio-frequency (rf) field. With this new tool of science, the bureau guarantees the accuracy of gauge block calibration down to 0.0000006 of an inch.



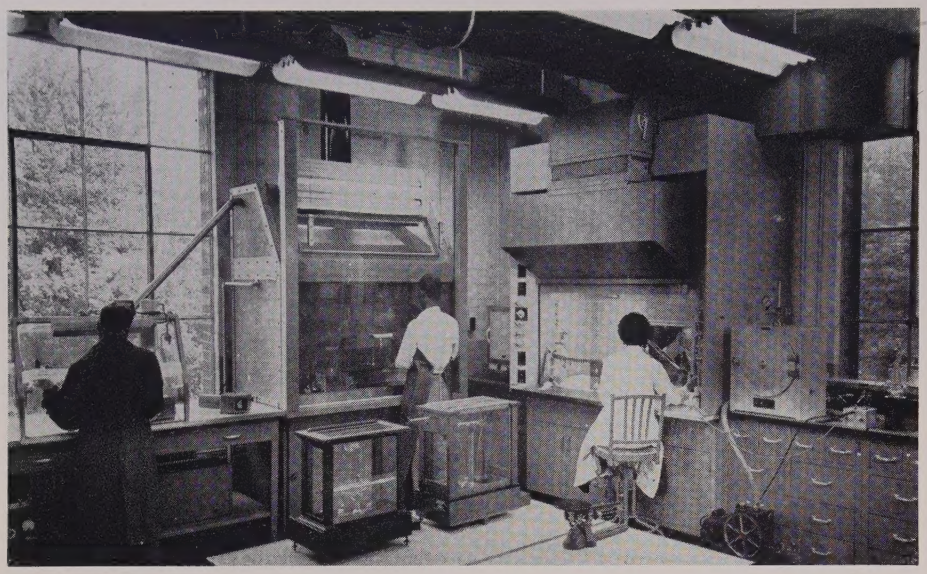
AERIAL VIEW OF NBS' NEW research center in Boulder, Colo., housing the Central Radio Propagation Lab.

New calibration gauges are needed, especially for the extremely large and the extremely small masses. All masses are compared to *working standards* prepared by doubling (or halving as appropriate) from the standard kilogram and comparing the resulting mass with the original standard kilogram cylinder. To obtain a two kilogram working standard, for example, a one kilogram cylinder is manufactured and compared with the standard until it is exactly one kilogram. Then another cylinder is prepared which will exactly balance these two on a beam balance. This, then, is a two kilogram working standard. Larger working standards are prepared by continuing this doubling process until the desired mass is obtained. An example of a heavy mass comparison balance is the one thousand pound balance shown in the frontispiece.

Probably the biggest weighing job of the bureau is the determination of the weight of the earth. Using Newton's principle of universal gravitation, two steel cylinders, two small platinum balls, a quartz fibre, and a lot of mathematics, the weight of the earth was determined in a manner similar to that used in Physics 106 for the determination of "G", the constant of universal gravitation.

One application of the bureau's mass standards (and gravity) is the usage of large *force gauges* in the calibration of large million-pound testing machines such as the large machines in Talbott Lab. The traditional method consists of inserting a calibrated *proving* ring into the machine and applying sufficient force to deform it to a predtermined point, the calibration point. The main difficulty with this method is that although proving rings can currently be manufactured up to a capacity of 300,-000 pounds, the largest that can be calibrated in the bureau's dead weight machine is 100,000 pounds. The new method utilized a *wire strain gauge*. This strain gauge measures the distortion of an object by virtue of the fact that a piece of special wire changes its electrical resistance when stretched or compressed. Using four 3-million pound dynamometers (wire strain gauges), loads up to 12-million pounds can be calibrated.

Another current project is the redetermination of the acceleration due to the force of gravity, "g." the last determination, made about twenty years ago, used the pendulum method. In this method the period of oscillation of a pendulum of known weight and length is measured. With the latest developments in accurate timing mechanisms, it is felt that a more accurate determination of "g" can be made by falling body method. In this method the time



INTERIOR OF "HOT LAB" in the radio-chemistry laboratory. Here solutions of radio-active materials are prepared for use as standard samples.

required for a ball to fall freely in a vacuum is measured and its acceleration determined mathematically. It is hoped that an accuracy of three parts in 10 million can be achieved.

The bureau recently completed two separate evaluations of the speed of light, a constant of ever-increasing importance in modern physics. Before World War II, the value 299,776±4 kilometers per second was generally accepted as an average of the findings of the various laboratories. Since the war higher values have been obtained by most investigators, largely through measurement of the velocity of propagation of microwaves (radio waves travel at the speed of light). The new value of 299,793±1 km/sec was an average of the values obtained through the new determinations. The first of the new determination used the *molecular constants* method. The exact procedure is quite complicated, but it's essence is one of measuring the spectral lines of carbon monoxide, both the absorption spectrum and the emission spectrum. The value obtained was 299,792±6 km/sec. NBS used a variation of the method originally suggested by Dr. A. E. Douglas of Ottawa, Canada.

The second new determination employed the *radio-interferometer* method, and was performed by the new Radio Propagation Laboratory in Boulder, Colorado. For the interferometer method, two receiving antennas were accurately spaced 1,500 meters apart on a flat dry lake bed. By varying the position of a transmitter over a path which half-way encircled the two antennas, the phase difference between the two was made to change. The wave-length of the radio waves was then calculated by dividing the accurately known distance between the receiving antennas by one-half the total change in phase difference. The value obtained was 299,795.1±3.1 km/sec.

Other Activities

Mathematics has become so closely integrated into scientific research that the bureau has established extensive facilities in the field of applied mathematics. Perhaps the most famous mathematical venture of the bureau was the National Bureau of Standards Electronic Automatic Computer (SEAC). SEAC is a somewhat typical example of the current trend in electronic digital computing mechanisms: ultra-high-speed computing elements combined with very extensive data storage (millions of binary digits). Many scientific problems are solved on digital machines by using approximation formulae, recomputing over and over again until the desired degree of accuracy is obtained. Another type of scientific problem is one in which a relatively simple equation is solved for an extremely large number of increments of the variable (e.g., the position of a planet in space over a span of centuries in increments of a few days each). Some of the recent computations were: preparation of high-temperature thermodynamic tables; computation of vibration modes and frequencies; velocity of light calculations; transient heat flow problems; stresses in a wall foundation; temperature distribution in solid wings heated aerodynamically; distribution of light output from neutron spectrometers; integral of a product of bessel functions; and many others.

The mathematics section also has extensive analog computer facilities which have done significant work in such things as vibration analysis, computing radioactive fallout, and solution of tactical strategy problems (involving up to six nonlinear differential equations). NBS does research into the problems of data processing systems, including investigations of magnetic cores as memory elements, circuitry of ultra-high-speed switching and computing elements and computer bulk reduction.

Boulder, Colo., is also the home of the Cryogenic Engineering Laboratory. The results of the bureau's cryogenic (low temperature) investigations have been responsible for many large-scale industrial applications of the liquified gases: oxygen, nitrogen, hydrogen, and helium. All of the nation's helium, for example, is concentrated by low-temperature processing.

Low-temperature properties of common materials have long puzzled scientists and engineers. At these low temperatures free-machining leaded copper becomes almost as highly conductive as high purity commercial copper, rubber becomes brittle, and many other unusual phenomena become manifest. The bureau is currently preparing a comprehensive bibliography of many of these low-temperature mechanical properties.

The radio propagation laboratory in Boulder has contributed much to our knowledge of radio propagation over long distances through the outer atmosphere, information about solar noises from our sun and from outer space, and development of long distance VHF and UHF transmission through a phenomena known as *tropospheric forward scatter propagation.* In order to assist long distance communication, the bureau's observations and predictions are published monthly to assist broadcasters in proper selection of broadcasting bands for best reception.

Cosmic and solar radio waves reaching the earth from outer space limit the minimum usable signal levels for FM broadcasting, television, communication and radio navigation services in the very-high-frequency (VHF) range.

Observations of the intensity of this cosmic noise by the bureau provide a sensitive indication of the absorption undergone by radio waves in passing through the ionosphere. Along with their studies of the effect on Arctic ionospheric propagation about the auroral absorption zone, these upperatmosphere observations provide an excellent beginning toward a complete understanding of all aspects of radio wave radiation.

Useful VHF and UHF transmissions are not limited to line-of-sight as was previously supposed. By using tropospheric forward scatter propagation, reliable transmission to distances of approximately 400 miles has been demonstrated using high-power transmitters and directional antennas. This phenomenon is believed to result from scattering of radio waves by very small inhomogeneities in the refractive index of the atmosphere. This development may

eliminate the need for many television and microwave relay stations currently dotting the countryside.

Accurate timing devices are of paramount importance in all scientific activities and the bureau is constantly seeking new and more accurate clocks and timing mechanisms. The bureau is now working on an ammonia-beam oscillator to be used as an atomic frequency and time standard of high accuracy patterned after the one recently developed by Columbia University. Experiments at Columbia have shown a precision of 1 part in 600 million, achieved with simpler equipment than is used with either the bureau's ammonia-absorption clock or cesium-beam clock. In the "atomic clock," the resonant absorption of microwaves in ammonia gas provides the frequency control element of a time-measuring device that can be made precise and completely independent of any vagaries in the period of the earth's axial rotation.

Perhaps the bureau's best known activities are its radio stations: WWV (Beltsville, Md.) and WWVH (Maui, T.H.). They continuously broadcast standard radio and audio frequencies, standard time intervals, time signals, standard musical pitch, and radio propagation disturbance warnings to the world. Standard musical pitch of "A" above middle "C", 440 cycles per second, is transmitted to a high degree of accuracy for industrial usage as well as for musical calibration. The Baltimore Symphony obtains its "A" from this tone.

This is only a small portion of the many activities carried on by the bureau. Space does not permit mentioning some of their many other projects: structural and industrial materials testing, instrument calibration, medical and dental research, chemical research, and the many, many others currently being carried on. It is hoped that this gives a little more insight in *Our Nation's Yardstick.*

The author is deeply indebted to the National Bureau of Standards for their generous contributions of reference materials as well as the numerous photos used throughout the article, our frontispiece, and our cover.

Safety on the Job

From first excavation to final clean-up, 691 days and 750,000 man-hours of work, not a single employee suffered a disabling injury in construction of an insurance company building in Minneapolis, according to *Construction Methods and Equipment.* Twenty-three accidents had been expected, based on the average for the type of job. It was the first major building ever erected in the Minneapolis-St. Paul area without a disabling injury.

your first move
CAN DECIDE THE GAME
your first job
CAN DECIDE YOUR FUTURE

That important first job can start you off in the wrong direction—*or* it can lead you straight toward your goal. If your ambitions are high, Motorola has a place that will give you the *finest* chance possible for the advancement you want. You'll get security and good salary, but, more important, you'll be working on projects with a *future*, like missile guidance, radar, and microwave. The door is wide open at Motorola, and the opportunity to fulfill your ambitions is *yours.*

If you are an ELECTRICAL ENGINEER, MECHANICAL ENGINEER or PHYSICIST, contact Motorola today.

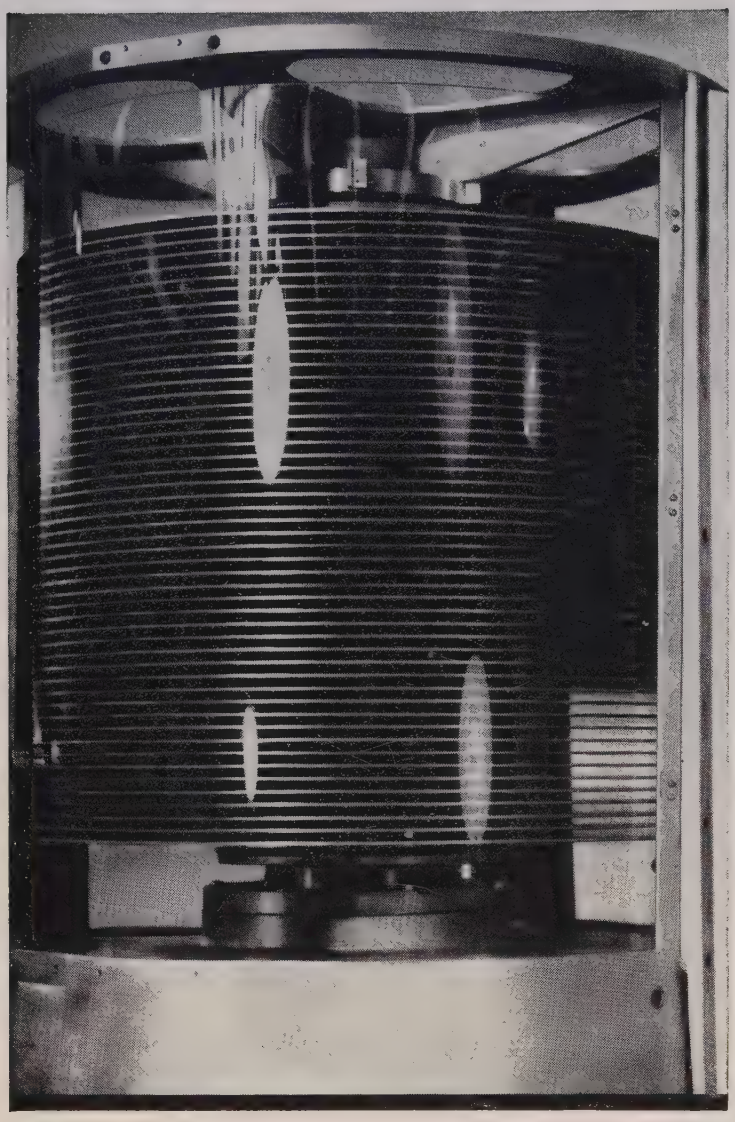
CHICAGO, ILL.: MR. L. B. WRENN, Dept. CO., 4501 Augusta Blvd.
Challenging positions in Two-Way Communications, Microwave, Radar and Military equipment, Television (Color) and Radio Engineering.

PHOENIX, ARIZ.:
RESEARCH LAB., MR. R. COULTER, Dept. CO., 3102 N. 56th St.
SEMI-CONDUCTOR DIV., V. SORENSON, Dept. CO., 5005 E. McDowell Rd.
Outstanding opportunities in the development and production of Military equipment and Transistor products.

RIVERSIDE, CAL.: MR. C. KOZIOL, Dept. CO., Box 2072
This new modern research laboratory, located 65 miles from Los Angeles, needs men in Missile and Military equipment systems analysis and design.

Contact your Placement Officer for further information regarding interview date on your campus or write to one of the above addresses.

MOTOROLA

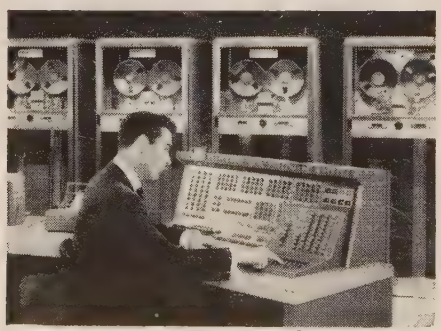


Machine with "millions" on its "mind"

These whirling disks are the heart of RAMAC®—IBM's revolutionary new random access memory data accounting system. Capable of storing from *6 to 24 million* digits in its metal mind, RAMAC offers an entirely new approach to the problems of data maintenance and storage.

RAMAC is a storage instrument permitting management to reach facts almost instantly, without searching or sorting. It supplies immediate, automatically typed answers to queries put to it. For the first time, it makes possible "single step" data processing—the simultaneous processing of transactions *as they occur*. This new wonder tool for American business means record keeping with greater speed, range flexibility and economy than was ever before possible.

Oil spotter: IBM computers sift thousands of oil samples, enable geophysicists to strike gushers sooner.



File detective: IBM electronic "giants" search criminal dossiers in seconds, speed law enforcement.

What YOU should remember

RAMAC typifies the electronic wonders being brought to reality at IBM. If you are preparing yourself for an electronics career, you'll find IBM offers excellent opportunities for rapid advancement in the virtually "unlimited" field of electronic computers. A growing company in a growing field, IBM means a chance for you to develop quickly to the fullest extent of your capabilities.

FOR FURTHER INFORMATION
about IBM opportunities,
see your Placement Director
or write to R. W. Hubner,
Director of Recruitment, Dept. 3312,
International Business Machines Corporation,
590 Madison Avenue, New York 22, N.Y.

IBM® INTERNATIONAL BUSINESS MACHINES CORPORATION

- DATA PROCESSING
- ELECTRIC TYPEWRITERS
- TIME EQUIPMENT
- MILITARY PRODUCTS

Building the Suez Canal

by Harry Hirsch, E. E. '57

In recent months, the Suez Canal has appeared in black headlines with startling regularity. This strategic waterway, once considered perhaps as remote as the land of Oz, has impressed itself on the mind of persons throughout the world as a means of starting or preventing World War III, a shortcut to the East, a vital oil-line, and an outpost of "colonialism vs. nationalism." These political considerations may not seem of vast import to the average engineer, until he thinks of them in terms of "do I have to go there?" Then the topic takes on greater meaning and interest. This article is taken, not from the point of view of the political situation, but the history and engineering background of the vital waterway, whose construction some said would result in a dry ditch and others said would flood all of Egypt.

The story of the modern-day Suez Canal is the story of the triumph of one man, Ferdinand de Lesseps, the French engineer, statesman and diplomat. Yet the idea of a canal across the Isthmus of Suez connecting the Mediterranean and Red Seas was not original to him, nor to our own era. Some geologists have said that at one time the seas did join, or that the Nile River had connected the two.

Some say the fertile Wadi Tumilat extending east of the Nile Valley, almost to the head of the Gulf of Suez afforded an easy route as the Red Sea Gulf extended north to the Bitter Lakes. Aristotle, Strabo and Pliny attribute the legendary Egyptian ruler Sesostris with the distinction of being the first of the Pharoahs to build such a waterway. An inscription at Karnak seems to bear out the fact that a canal existed at the time of Seti I (1380 B.C.). In fact the channel of this canal is still traceable in parts of the Wadi Tumilat and its direction was frequently followed by engineers of the fresh-water canal from Cairo to the Suez Canal during the latter-day construction. Other sources connect this construction to Nechos, son of Psammetichus, who undertook the job around 700 B.C. After wasting the lives of 120,000 Egyptians, he desisted according to the warning of the Oracles, who prophesied foreign invasions if the canal was completed. It was resumed some time later and completed by the Pharoahs. It ran from Suez to the Bitter Lakes, across the Lakes to El Quady and from El Quady to Zagazig on the Nile, a distance of 92½ miles. A writer by the title of El Kendi says it was cleared in 645 B.C. within six months. Some say Darius the Great, the Persian ruler, continued the work of Necho, rendering navigable the channel of the Heroopolite Gulf, which had become blocked. Up to this time there appears to have been no connection between the waters of the Red Sea and those of the Bubastis (Zagazig) - Heroopolis Canal. Herodotus, the frequently windy Greek historian, described the canal on his visit to Egypt as being wide enough to carry two vessels abreast. It was from 100 to 150 feet wide and very deep. Plutarch describes Cleopatra as attempting to escape after the Battle of Actium, but her vessels were stopped by the want of water in the Nile.

The Roman emperor Trajan, reopened the Canal about 98 AD., bypassing an old branch of the Nile which had dried up and connecting the new canal with Bubastis and Old Cairo. This new canal was known traditionally as Amnis Trajanus or Amnis Augustus. It was once more abandoned being repaired in the days of the Caliphs during the sixth century AD. It was closed again around 750 by Mansur the second Abbasid Caliph and founder of Baghdad wished to prevent supplies from reaching Arabia by this means. This canal was said to have its terminus on the Red Sea near the present town of Suez. Some say it was restored by Sultan Hakim in 1000. It must have filled rapidly and continued to be filled during Nile floods until Mohammed Ali in 1811 ordered it to be closed. This

FERDINAND DE LESSEPS, builder of the Suez Canal.

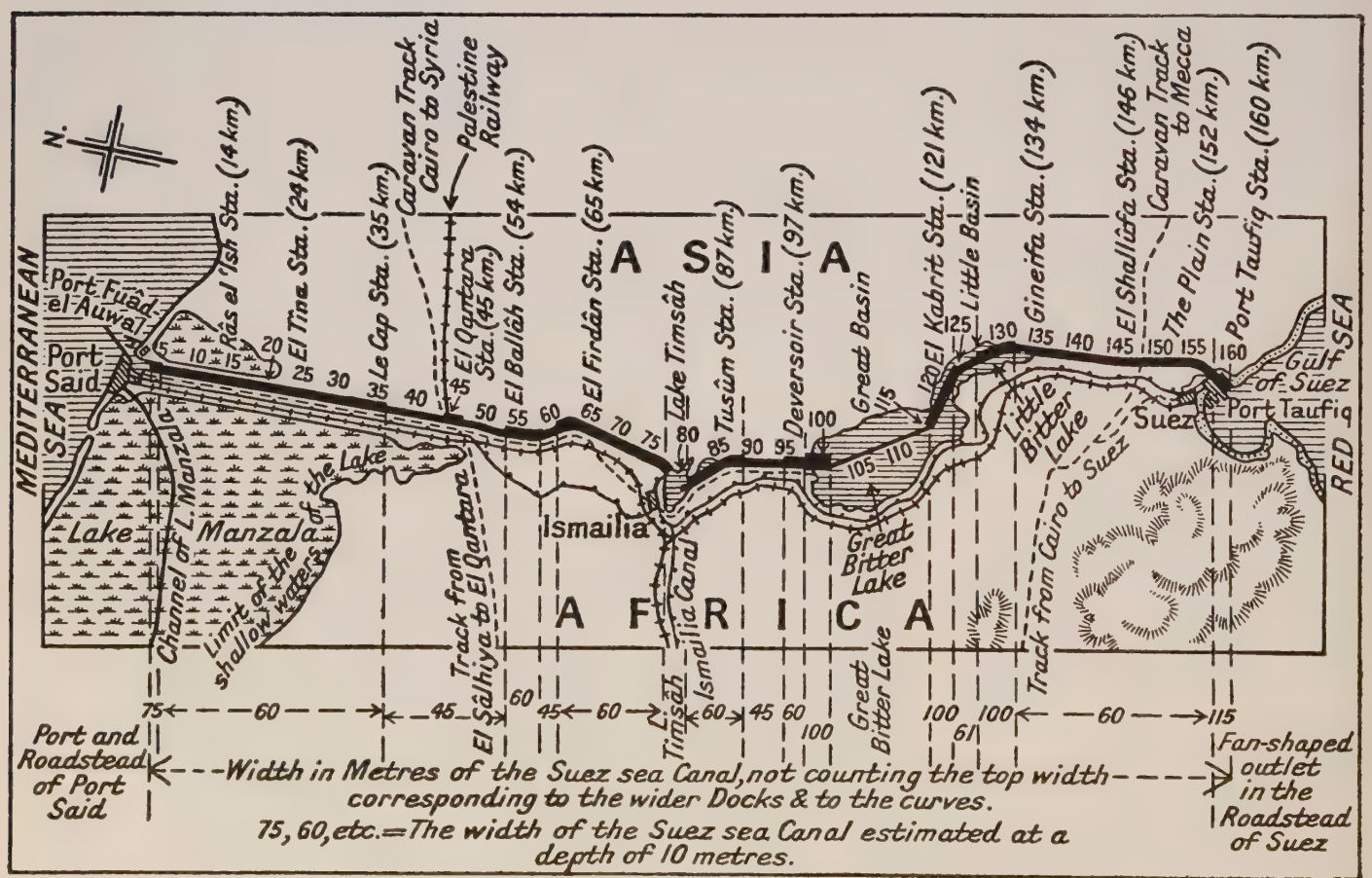
VIEW OF ONE OF THE CANAL'S bypasses near Ballah showing flatness of land the canal traverses. (Photo from Life magazine)

closing was not completely carried out for in 1861, the old canal stilled flowed in parts and was utilized by the French engineers in 1861-63.

In 1671 Leibnitz proposed to Louis XIV of France an expedition to Egypt to build such a canal. When Bonaparte conquered Egypt in 1783 he ordered a survey and engineer J. M. Lepere reported an erroneous difference of 29 feet between the Red and Mediterranean Seas. Lepere then said, "It is therefore certain that after due study of the surveys we have made, the Delta is liable to be innundated by the waters of the Red Sea, and that the fears entertained by the ancient Egyptians of submersion in case a canal were made, were well founded, in past times, when the Delta, and the bed of the Nile were undoubtedly at a lower elevation." The mistake was pardonable considering the rude and dangerous circumstances the survey was made under.

In France, however, La Place and Fourier, said Lapere ought have his transits fixed, when they disagreed. Laplace said it militated with his theories of the system of the globe and the equilibrium of the seas. Lapere believed the canal should connect Suez with Alexandria via the Nile as it had in ancient times, thus carrying traffic through Cairo.

At this point Ferdinand de Lesseps entered the picture. His opportunity came in 1854 with the death of Abbas Pasha, Viceroy of Egypt. His friend, Said Pasha then became Viceroy. From Said, de Lesseps obtained a concession authorizing him to constitute the Compagnie Universelle du Canal Maritime de Suez which should construct a ship canal through the isthmus. Soon after he obtained the concession, in connection with two French engineers, Linant Bey and Mougel Bey, he decided the canal should run in a direct line from Suez to the Gulf of Pelusium on the Mediterranean, passing through the depression that is now Lake Timsa and the Bitter Lakes and skirting around


N.
MEDITERRANEAN SEA
RED SEA
Port Fuâd el Auwal
Port Said
Râs el 'Ish Sta. (14 km)
El Tina Sta. (24 km)
Le Cap Sta. (35 km)
Caravan Track Cairo to Syria
Palestine Railway
El Qantara Sta. (45 km)
El Ballâh Sta. (54 km)
El Firdân Sta. (65 km)
Lake Timsâh
Tusûm Sta. (87 km)
Deversoir Sta. (97 km)
Great Basin
El Kabrit Sta. (121 km)
Little Basin
Gineifa Sta. (134 km)
El Shallûfa Sta. (146 km)
Caravan Track to Mecca
The Plain Sta. (152 km)
Port Taufiq Sta. (160 km)
Gulf of Suez
Port Taufiq
Suez
Little Bitter Lake
Great Bitter Lake
Ismailia
Lake Manzala
Channel of L. Manzala
Limit of the shallow waters of the Lake
Track from El Qantara to El Sâlhiya
Track from Cairo to Suez
Ismailia Canal
Timsâh
A S I A
A F R I C A
Port and Roadstead of Port Said
Fan-shaped outlet in the Roadstead of Suez
Width in Metres of the Suez sea Canal, not counting the top width corresponding to the wider Docks & to the curves.
75, 60, etc. = The width of the Suez sea Canal estimated at a depth of 10 metres.
Sweet Water Canal from the Nile at Cairo to Suez via Ismailia (Ismailia Canal), and from Ismailia to Port Said (El 'Abbâsîya Canal).
Railway from Cairo to Port Said, and to Suez, via Ismailia.
Road from Port Said to Ismailia and towards Suez.
5, 10, etc. = Length in Kilometres of the Suez sea Canal.

TRACE OF THE SUEZ CANAL

the eastern edge of Lake Pensala. In the following year an international conference appointed by the Viceroy approved the plan with the modifications that the channel go through Lake Mensala and the northern terminus be moved 17½ miles westward to where deep water was found closer to shore.

Some mavericks disagreed with the commission's standpoint proposing an indirect route to cross the Nile on an aqueduct and be about 300 miles long. An English engineer abandoned the idea of a canal and proposed a railway. Some said the canal would never be made, but would always remain a stagnant ditch.

The ultimate plan, under which there would be no locks in the canal was adopted by a second conference in January, 1856. The company had the obligation to construct a fresh water canal from the Nile near Cairo to Lake Timsa with branches running parallel to the maritime canal to Suez and Pelusium. The concession was to last 99 years from the date of opening after which in default of other arrangements, the canal would pass into the hands of the Egyptian government. The confirmation of the Sultan of Turkey was required prior to construction and when de Lesseps went to Constantinople to secure it, he was baffled by British messengers who had reached the Sultan first with stories of French plans for domination of the East and an end to British maritime supremacy. The English Lord Palmerston had instructed the English counsel general in Cairo to oppose any attempt to construct the canal but work for a railway from Alexandria to Suez. Fearing the results of the railway, French officially supported the canal. The railway was completed in 1858.

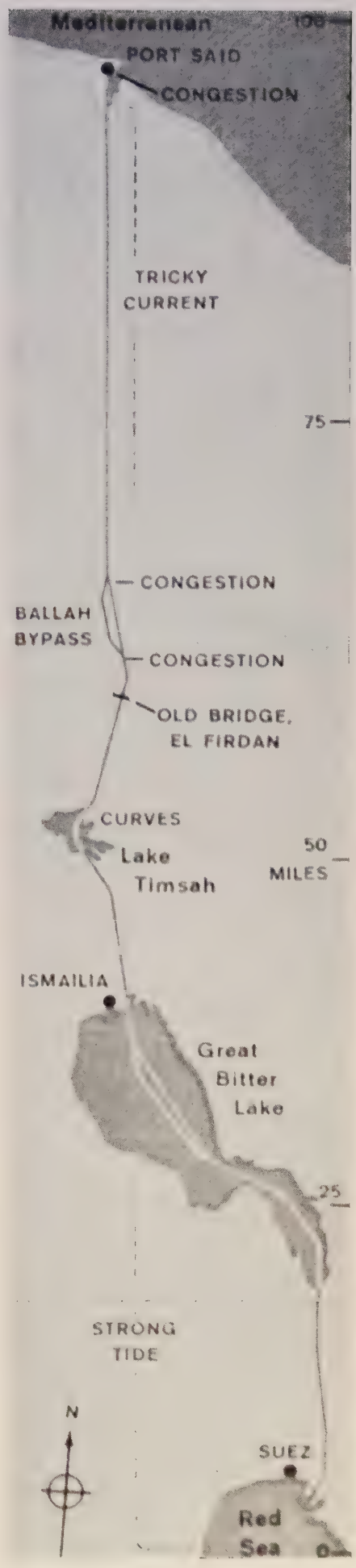
Although the Sultan's confirmation of the concession was not actually granted until 1866, de Lesseps in 1858 opened subscription lists for company capital with 400,000 shares of capital worth 500 francs each for a total of 200 million francs. In less than a month, 314,494 shares were applied for: of these over 200,000 were subscribed from France and over 96,000 were taken in the Ottoman Empire. Other countries took little note of the subscriptions. The residue of 85,506 shares was taken over by the Viceroy.

Work began in April of 1859 with the first spadeful of sand being turned over near the site of Port Said, but progress was not very rapid. By 1862, the fresh water canal reached Lake Timsa and toward the end of 1862 a narrow channel was formed between the Lake and the Mediterranean. In 1863, the fresh water canal continued to Suez.

The Suez Canal as an engineering work was spoken of later by de Lesseps as a task presenting less difficulty than a small French railway. However, being the first work of its kind, it seemed difficult because of all kinds of dangers which were assumed to exist. It is said that never was an undertaking so beset with imaginary obstacles as the Suez Canal. All along the course is a natural depression, the lowest portion being the basin of long dry lakes. At only two points does the ground rise much above the level of the sea, Serapeum, being about 36 feet above mean level and El Guiser, being 59 feet above mean level. Here cuttings were required but as a whole, the construction was fairly easy. There was difficulty at the northern end, where a new port had to be built free from shifting sands which would block up the mouth. A channel was dredged and jetties constructed out to sea. Some said treacherous quicksands would swallow every stone, but they were as usual, wrong. Once through the mouth, the canal entered Lake Mensalan, a shallow lake through which 29 miles of canal were dredged. A three mile channel left Mensalan and entered Lake Ballah for five miles, then reaching a hilly tract that extended for nearly ten miles to El Guisr. Once this plateau was passed, the canal entered the halfway point, Lake Timsah, where the dried up lake was changed into a basin four by three miles. Next the plateau of Serapeum, seven miles long and 36 feet high was cut into. Another stiff plateau near Geneffe was skirted and the Bitter Lakes were entered. The canal passed 20 miles through these bodies of water and then traveled straight to Suez, encountering the plateau of Chalouf on the way.

Thus the work consisted of digging the salt maritime canal, the connecting fresh-water canal and construction of the two cities of Port Said and Ismailia.

Most work had been performed by native labor. The concession of 1856 said 4/5 of the laborers should be Egyptians. Later Said Pasha undertook to supply laborers as required by the engineers of the canal company who were required to feed, house and pay them at stipulated rates. Although wages and terms of service were better than men obtained normally, the system of forced labor was strongly disapproved of in England and Khedive Ismail, who succeeded Said on the latter's death in 1863, also considered it as being contrary to the interests of his country. The Egyptian foreign minister, Nubar Pasha, then sent the company the proposal that the number of laborers furnished the company be reduced and the company should hand back to the Egyptian government the lands it had been granted in 1856 on penalty of having the



→

A MAP OF THE PRESENT-DAY Suez Canal showing navigational hazards. (Map from Life magazine)

work stopped by force. The dispute was referred to Emperor Napoleon III, who in 1864 said the company should be allowed 38 million francs as an indemnity for abolition of labor and 16 million francs in respect of retrocessions of the portion of the fresh-water canal between the Nile, Lake Timsa and Suez. Thirty million francs were awarded the company for lands granted it by Said. A certain amount of land along the canal was kept for shops, housing, etc. The 84 million dollar indemnity was to be paid for over a period of 15 years.

Abolition of forced labor led to increased mechanization and modern engineering methods. Soft material was readily removed by dredge, including 22 million cubic meters of sand or mud for the first 45 miles from Port Said. Sand was readily dredged by means of a preliminary channel being dug. Water was then admitted from the already-constructed fresh-water canal which was on a higher level and work was completed.

The canal was opened formally in November, 1869 with vessels of 68 nationalities entering Port Said. They were led by "Aigle" with the Empress Eugenie aboard.

Immediately prior to the opening, a ledge of rock was found below the surface, just north of Suez. Blasting powder was urged to either blast away the rock, or the builders if the rock wasn't blasted away in time. At its opening the canal was approximately 100 miles long; varying from 72 to 150 feet wide and more than 20 feet deep in all parts. "Sidings" were located every few miles, where ships could tie up at night, until safe night navigational lighting was introduced. While traffic grew, it grew slower than expenses and a rapid increase in revenues just saved the company from bankruptcy. Total construction expenses had totaled 432 million francs, based on an estimate of 200 million francs in 1856.

Improvements started in 1876 and increased in 1885 as the channel was widened and deepened. The time of transit varied from 36 hours in 1886 to around 12 hours at present. As the canal grew in stature, more British vessels used it and finally on advice that the Khedive of Egypt was in need of funds, the British government purchased his share of the canal stock to safeguard its interest in the canal in 1875. A total of 176,000 shares was purchased by Britain.

At present, or prior to hostilities, the canal had 200 pilots whose task was to guide vessels through its channel. Since 1948 vessels travel in convoys, with northbound ships having the right of way. Southbound vessels pull into the Ballah Bypass, about ¼ of the way from Port Said or the Great Bitter Lakes. The average width of the canal is 190 feet. Due to complexity of tides from the Red Sea as well as tricky navigation around curves, pilots change at Ismailia, the halfway point, working from Ismailia, north to Port Said, or south to Suez. The reverse directions are taken by other pilots. A pilot never navigates a ship through the same channel in both directions, due to the difficulty in memorizing landmarks from two directions.

One can say little about the future of the canal. Larger tankers are being built to circumvent its route, adding 5,000 miles to the voyage, but carrying more payload. Several vessels have been sunk by scuttling and/or air attacks. Perhaps the canal will be returned to dry ditch status, perhaps not. No matter what happens, the star of de Lesseps cannot be diminished by subsequent actions. After the construction of the canal, he achieved world-wide acclaim. In 1879 at the age of 74 he was named director of construction of the Panama Canal. His despotic temper and absolutness of thought made him fail to realize the difficulties of the task. He was determined to construct the canal without locks, even when confronted with the vast Culebra mountain and Chagres stream. In 1888 the Panama Company gave up. Seeking to discredit the government, enemies of the republic attacked directors of the company. The government was obliged to take proceedings against them. De Lesseps' son took the blows aimed at de Lesseps who died in 1894, a member of the French Academy, Academy of Sciences, wearer of the Grand Cross of the Legion of Honor and Star of India. His reputation died undimished by his last setbacks. Today, unless its has been pulled down by agitators, his statue stands at the entrance of the canal of Port Said, overlooking his dream.

DELESSEP'S MONUMENT stands, or stood, at the mouth of the canal at Port Said, a tribute to his genius.

so **CHALLENGING**
this industry...
so **REWARDING**
its opportunities
...and so **VARIED**
the careers it offers...

Alcoa wrote this book to tell the story

Few basic industries can match aluminum for speed of growth and diversity of activities. And Alcoa sets the pace for the aluminum industry.

Because of this growth and diversity, Alcoa needs outstanding young engineers who, someday, will take over many important management functions at Alcoa. Alcoa's book tells you this story.

If you are earning a degree in metallurgical, mechanical, electrical, industrial, chemical, civil or other engineering field, Alcoa wants to discuss your future with you. Alcoa's book tells you how to go about this.

Engineers who select a career with Alcoa will earn their professional recognition under the men who built the aluminum business. They'll gain their experience with the industry's foremost production equipment, such as America's biggest forging press.

They can share in new and startling research and development triumphs sure to come from Alcoa . . . for these new engineers will work with research teams that developed such products as the first 330-kv transmission line . . . the first aluminum curtain walls . . . all the important basic families of aluminum alloys. Alcoa's new book outlines this exciting future.

Or, if you prefer selling, Alcoa provides opportunities in sales engineering and sales development where salesmanship of the highest order is needed . . . and where recognition comes quickly. You'll find this excitingly portrayed in Alcoa's book.

See your Placement Director, or write directly for your copy of *A Career for You With Alcoa*. You'll find it stimulating and rewarding reading. Use the coupon for convenience.

Write for your copy

ALUMINUM COMPANY OF AMERICA
1825 Alcoa Building
Pittsburgh 19, Pennsylvania

Please send me a copy of *A Career for You With Alcoa*.

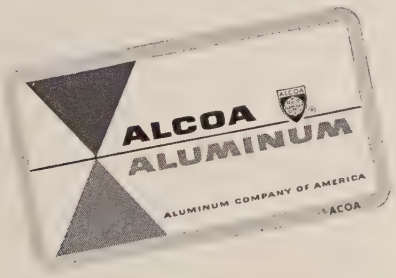
Name_____

Address_____

City and State _____

College_____ Degree_____ Date of Graduation_____

Your Guide to the Best in Aluminum Value



Tune in the ALCOA HOUR, television's finest hour of live drama, alternate Sunday evenings.

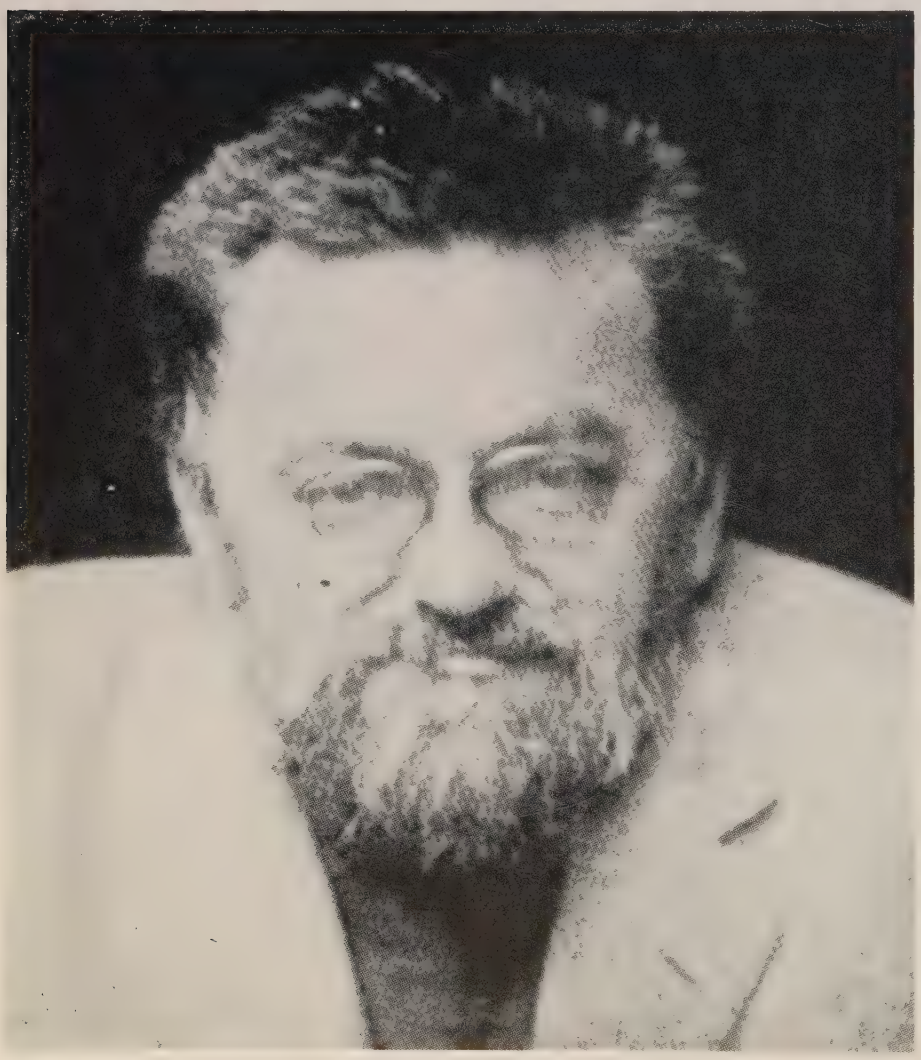
Electrical Wizard . . .

CHARLES PROTEUS STEINMETZ

by Dotty Hazel, Eng. Physics '59

On April 9, 1865, a son was born to Mr. and Mrs. Carl Heinrich Steinmetz. Mr. Steinmetz was quite worried when his child was born for he knew his child would be deformed. Hadn't his father been deformed? Wasn't he himself, deformed? When the midwife brought his new son to him, he was afraid to look. He asked if the child was all right. She said yes, that he only had a small hump on his back and a slightly crooked leg. Mr. Steinmetz breathed a sigh of relief. The little boy was named Karl August Rudolph Steinmetz.

A year after little Karl's birth, his mother died and his grandmother came to take care of the family. She spoiled little Karl terribly. He became almost too intolerable to live with. He gave his "Grossmutter" no end of trouble.



CHARLES PROTEUS STEINMETZ, General Electric's Engineering wizard.

Grossmutter was little Karl's playmate. They spent many happy hours together. He never thought he would ever be away from Grossmutter. This was the reason he didn't care for kindergarten. He stayed one day but put up such a fuss when he was supposed to go back, that Grossmutter didn't have the heart to make him go.

Luckily, when Karl was started to school he became so interested in what he was doing in school that he didn't mind being away from Grossmutter for awhile. He spent three years in elementary school, and at the age of 8½ he started to the gymnasium.

In the gymnasium Steinmetz studied for nine years. He studied Latin throughout the time he was there. He also studied French and Greek. His other subjects were Polish, Hebrew, philosophy, and various mathematical subjects. Mathematics turned out to be his favorite. Steinmetz was the honor man in his class at the gymnasium. He was the only one on the honor list, which meant he didn't even have to take part in the graduation ceremonies and therefore no examination.

In 1882 came the biggest change so far in Steinmetz' life. He entered the University of Breslau where he studied for six years. He took such elaborate notes that they called for independent work. Therefore, he set up a makeshift laboratory in his room at home, where he spent many hours.

Steinmetz was known to attend every lecture in each course he was studying. This was almost unbelievable. Students attended only when they felt like it. The only thing that was required was that they pass the examinations when given. In his last year at the university, Steinmetz took math, astronomy, theoretical physics, chemistry, medicine, and electrical engineering. He was very versatile in his studies.

Besides being what students today might call a "grind," Steinmetz was well liked by other students. He loved to laugh and joke with them over a beer. He was just as good at merry-making as he was at his studies. After he had been in the university a short while he joined the mathematical society. The society held their meetings in a restaurant, where they could mix business and merry-making. It was not unusual for these meetings to last out the night. The society always gave each of its members a special name, a nickname by which the member is always known thereafter. Steinmetz was dubbed Proteus—a name which he later adopted permanently.

It was at a math society meeting

that Steinmetz was invited to a secret Socialists meeting. This was a big thrill to him. He became a Socialist. Actually though, it was only a game to him. He was in it solely for the excitement which he got out of it. *"The People's Voice,"* which was the Socialist paper at the time, soon had Steinmetz as its editor. This was fine until the police finally had enough information about Steinmetz's Socialist activities for his arrest. Luckily, Steinmetz was informed of the arrest by friends in time to get away.

Steinmetz went to Switzerland where he wanted to study at Zurich Polytechnic. He had trouble getting in the school because students had to show a certificate of residence from where they had lived before coming to school. Of course, Steinmetz had none. Fortunately, however, he made friends with an influential resident and managed through him to register at the school.

At a friend's home, Steinmetz, who was discussing electricity with one of his fellow students at the time, overheard a Dane talking about a land which sounded like heaven. Steinmetz was immediately interested. The Dane was named Asmussen. He had been living in San Francisco with his uncle. Steinmetz got acquainted with Asmussen, and they became great friends. They roomed together while they studied at the Polytechnic. Then Asmussen fell in love. The uncle in San Francisco, who was supporting Asmussen, sent for him immediately after he found out Asmussen wanted to get married. Asmussen decided to follow his uncle's wishes and asked Steinmetz if he would like to go along. This was what Steinmetz had been waiting for! But he had no money. Asmussen had enough money to take them both to America if they traveled steerage. This they decided to do.

The immigration officials did not get a very pleasant picture of Steinmetz. He had caught a cold on the voyage. His face had swollen up as a result and his eyes were almost swollen shut. The officials saw a little dwarf, sick, in tattered clothes, with no money, no job, and unable to speak English. He'd have to go back! At this point Asmussen intervened. In fluent English, he explained that Steinmetz was a world famous mathematician and pulling out a handful of paper money from his pocket, swore that it belonged to Steinmetz. The officials relented and let Steinmetz stay.

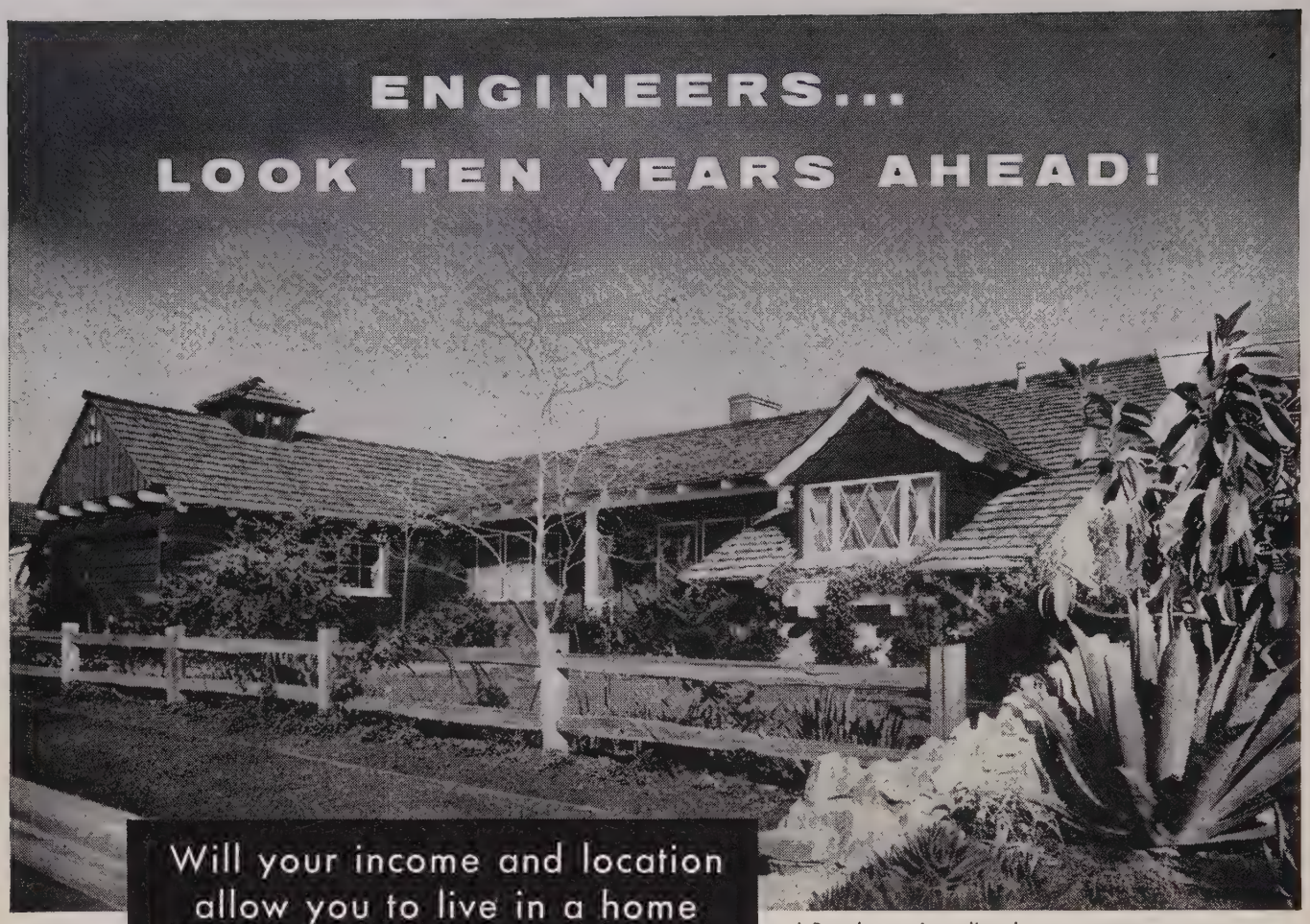
Steinmetz was elated to be in America. He loved it the moment he saw it. He and Asmussen stayed with some of Asmussen's relatives in Brooklyn. Two weeks later he found a job. He was a $12.00 a week draftsman for Rudolf Eichemeyer, a fellow German. Steinmetz's genius was evident only when he could talk. His appearance certainly didn't show it, and neither did his broken English. However, Mr. Eichemeyer had Steinmetz speaking in his own language and could see that he was a prize catch. Steinmetz was so happy to be a self-supporting immigrant after being in this wonderful country for only two weeks that he went immediately from Eichemeyer's office and took out his first naturalization papers.

ALTHOUGH EINSTEIN and Steinmetz rarely met, the two minds easily communicated with each other at the high levels which they were used to operating on.

Eichemeyer's plant was chiefly concerned with the making of hat machines. It was not very electrical; however, Eichemeyer was very interested in the improvement of his plant through electrical apparatus. He could see great things ahead for electricity and therefore he put Steinmetz to the task of improving what electrical equipment he had.

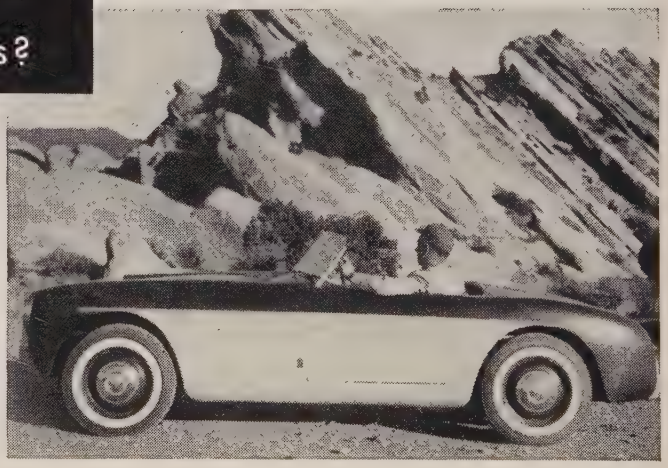
At this time Edison had invented the incandescent lamp. Now there was an up and coming need for better transformers and generators. The unscien-

ENGINEERS...
LOOK TEN YEARS AHEAD!



Will your income and location allow you to live in a home like this...spend your leisure time like this?

A Douglas engineer lives here



They can...if you start your Douglas career now!

Douglas has many things to offer the career-minded engineer!

...there's the stimulating daily contacts with men who have designed and built some of the world's finest aircraft and missiles!

...there's enough scope to the Douglas operation so a man can select the kind of work he likes best!

...there's security in the company's $2 Billion backlog of military and commercial contracts!

...and there's every prospect that in 10 years you'll be where you want to be professionally, and you'll be in both the income level and geographical location to enjoy life to its full.

Brochures and employment applications are available at your college placement office.

For further information about opportunities with Douglas in Santa Monica, El Segundo and Long Beach, Calif. and Tulsa, Okla., write today to:

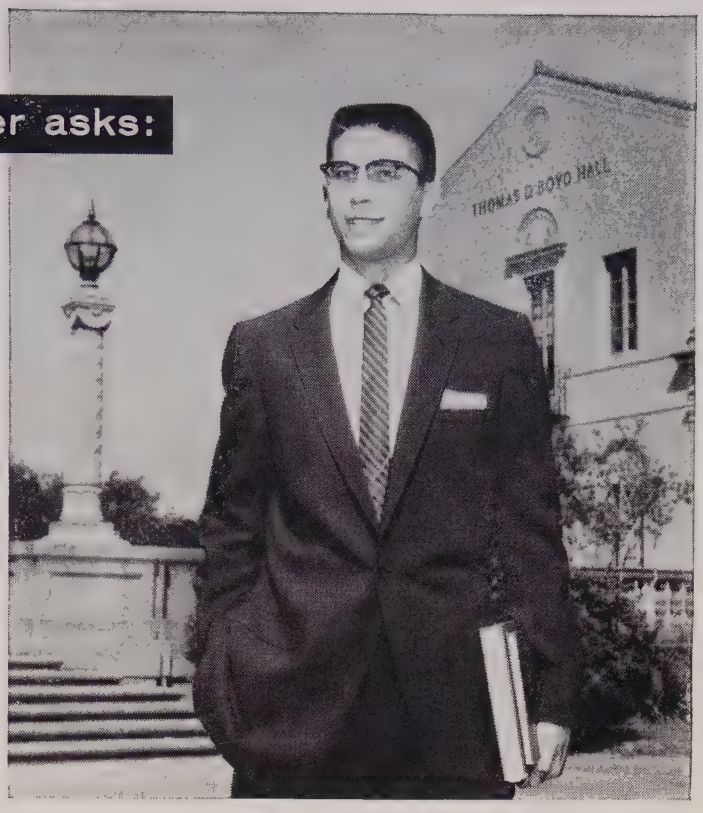
DOUGLAS AIRCRAFT COMPANY, INC.
C. C. LaVene, 3000 Ocean Park Blvd.
Santa Monica, California

DOUGLAS

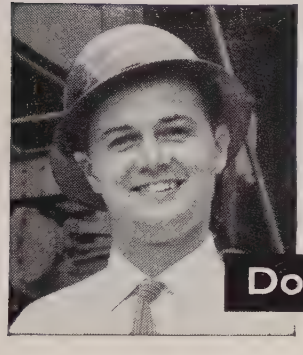
First in Aviation

Oran Ritter asks:

Does Du Pont hire men who have definite military commitments?



Oran A. Ritter, Jr., expects to receive his B.S. in chemical engineering from Louisiana State University in June 1957. He's now editor-in-chief of the "L.S.U. Engineer," local president of Tau Beta Pi, and senior member of the Honor Council of his university. Oran's question is on the minds of many men planning a technical career.



Don Sutherland answers:

Donald G. Sutherland graduated from Virginia Polytechnic Institute in 1953 with an M.S. degree in chemical engineering and an R.O.T.C. commission. He was hired by Du Pont's plant at Victoria, Texas. After two years in the service, Don returned to his career in engineering, and is now doing plant-assistance work in the technical section at Victoria.

YES, Oran, we certainly do! We've employed quite a number of college graduates with definite military commitments, even when we knew they could work no more than a few weeks before reporting for duty. Take my own case. I was hired in November of 1953 and worked for only four weeks before leaving for the Army. Two years later I returned to Du Pont.

You see, we're primarily interested in men on a long-range basis. The fact that they're temporarily unavailable, for a good reason like military service, isn't any bar to their being considered for employment. After working only one day, an employee is guaranteed full re-employment rights—that's the law. And if a man works for Du Pont a full year before entering the service for two or more years, he receives an extra two months' salary. If he goes into the service for six months, he's paid a half month's salary. When he's entitled to a vacation but doesn't have time to take it before leaving, Du Pont gives him equivalent pay instead.

Even if present employment is impossible, Oran, we definitely recommend your talking with Du Pont's representatives as well as those of other companies. The very least you'll gain will be valuable background and some contacts of real benefit to you when you leave military service.

WANT TO KNOW MORE about working with Du Pont? Send for a free copy of "The Du Pont Company and the College Graduate," a booklet that tells you about opportunities for work in all departments of the Company. Write to the Du Pont Company, 2521 Nemours Building, Wilmington, Delaware.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Watch "Du Pont Theater" on television

tific methods used by the researchers of the time to develop these things did not meet with the approval of Steinmetz and Eichemeyer. They tried to do their research in an orderly fashion. Steinmetz began to formulate certain theories.

Eichemeyer could see the value of Steinmetz's work, so he relieved him of his routine work and let him "play" around with electricity to his heart's content. Eichemeyer would pat Steinmetz on his back for doing such remarkable work. Then he would would pat himself on the back for recognizing the genius in the frightened little immigrant.

Steinmetz joined the American Institute of Electrical Engineers. He said hardly a word at all at the meetings for he was afraid his English would fail him. Then on January 19, 1892, he presented his paper on the Law of Hysteresis. Many of the members of the A.I.E.E. didn't even understand it, for it was too far over their heads. However, they did realize its importance. Those who did understand it applauded loudly. There, at the age of 28, he took his place among the top ranking electrical engineers of the time.

Now Steinmetz really wanted to be all-American. America appreciated him. Germany had not. As he was signing a check one day in Eichemeyer's plant he looked at his name—Karl Rudolf Steinmetz. He tore up the check and started over. This time he signed it Charles Steinmetz. But all Americans have a middle name. He tore the check up again. This time he signed it Charles P. Steinmetz. The P. stood for Proteus. Now he felt he was really Americanized.

In 1892, the General Electric Company was formed. It had $35 million backing and a big supply of prestige. This prestige included Steinmetz. When the company was first formed, it looked around for all the patents concerning electricity and bought them. Naturally it eventually came to Eichemeyer. G. E. bought Eichemeyer's plant and patents. They were very generous. Eichemeyer soon found out why, for in the contract he signed, was a clause stating that he must persuade Steinmetz to work for the new company. This Eichemeyer did. It was a good chance for Steinmetz, but he was not happy to leave his friends.

Steinmetz moved to Lynn, Massachusetts, where the G. E. engineering staff was located. His first job was to work on and improve G. E.'s transformers. G. E. did not have much business at this time because money was so tight. As a result, they laid off many of their employees. They considered Steinmetz too valuable to lose, however, so they kept him. He hadn't much to do, so he spent his time working on abstract problems. He was developing his theories on alternating current.

Steinmetz went to the World's Fair in Chicago for G. E. had an elaborate display there, and they wanted to make sure everything was kept in running order. Steinmetz was intrigued by the Fair. When he got back to Lynn, he found the engineering staff packing up to move to Schenectady.

By the time the move was made to Schenectady, Steinmetz had finished his paper on alternating current. It was a symbolic method of calculating alternating current. He wrote it in three parts: Theory, Theory and Practice, and Practice. The manuscript constituted nearly a cubic foot of closely written pages!

Steinmetz presented his paper to the International Electrical Congress. Most of the members couldn't understand it. Besides, the Congress could not afford to present such a huge paper and it laid around until McGraw-Hill Company was persuaded to print it. Now these volumes are classics of electricity.

In the meantime Steinmetz was using his symbolic method in his work at G. E. The only people who understood what he was doing were a few engineers intelligent enough to understand Steinmetz's explanations. It really did not matter that he was not understood. G. E. was satisfied with the results. That was what counted.

Steinmetz was soon made head of the calculating department. This worked out fine until the department began to grow. Steinmetz was a scientist, not a business manager. He didn't distribute the work properly. It was too much bother for him. Things went from bad to worse. The calculating department wasn't getting routine problems solved. The officials of the company did not quite know what to do. They couldn't demote him at the risk of hurting his feelings. Finally they hit upon a superb idea. Steinmetz was made consulting engineer. He was given a good salary and an unlimited expense account for apparatus to do his own independent research.

This was an ideal setup—both for Steinmetz and G. E. Steinmetz was never happier than when at work on some interesting problem he had dreamed up and G. E. was always happy to get the results of those problems.

Steinmetz, by this time, was becoming a public figure. The papers loved to play up human interest stories and he was good for an almost endless amount of these. In the papers, Steinmetz stood for something "mysterious and amazing." Of course the G. E. Publicity Department didn't mind this at all. It was extremely helpful to sales.

The position of consulting engineer gave Steinmetz the time to work as he pleased. Gradually, he moved his apparatus to his home. This was the most productive time of his life, his greatest achievement being his development of a method for dealing with alternating current.

Because he was doing his work at home, Steinmetz began to have landlord trouble. They seemed to object to charred ceilings and had no sympathy for it even in the cause of science. Consequently, Steinmetz decided to build a house of his own that, if necessary, could burn down in the cause of science.

The laboratory was built first, naturally. There were two rooms above the lab. Steinmetz slept in one. He was very happy in the lab for awhile, but he began to get lonely, he told G. E. he needed an assistant. G. E. promptly satisfied his request and sent Mr. Hayden, a young engineer, to work with Steinmetz. This was a young engineer's dream come true. Mr. Hayden considered himself *very* lucky and it was not long until Hayden occupied the other room above the lab.

Soon Steinmetz's house was finished. It was so big, however, he refused to move in. It would be too lonely. Then Hayden got married and Steinmetz was again alone. He called on the Haydens often and then asked if they would live with him in his new house. They accepted and Steinmetz had an adopted family. He became "Dad" to both Mr. and Mrs. Hayden. And soon, he had grandchildren.

Shortly after Steinmetz's acquirement of a family, several honors were given to him. He was made president of the A.I.E.E., Harvard made him a Master of Arts, and Union College of Schenectady made him a Doctor of Philosophy. He also began lectures at Union College. The students did not learn much math from him—he was too far over their heads—but no teacher ever gave them more inspiration. The lenient position with G. E. allowed him to do this for ten years.

Steinmetz built a crude camp along the banks of the Mohawk. Many said the camp resembled its owner—frail and crooked. He damned up a pond behind the camp where he spent many hours drifting around in his canoe while his "grandchildren" splashed happily nearby. He would put a writing board across the gunwhales of the canoe, take along a stack of paper and a box well supplied with sharpened pencils and long thin cigars, then drifting around his little pond, the sun beating down on his back, he would work out intricate mathematical formulae.

Steinmetz died at the age of 58. His body simply quit functioning. His death was quiet and peaceful. There was no sign of pain. He simply went to sleep and never awoke.

Three and one-half tons of . . .

Bugatti Royale

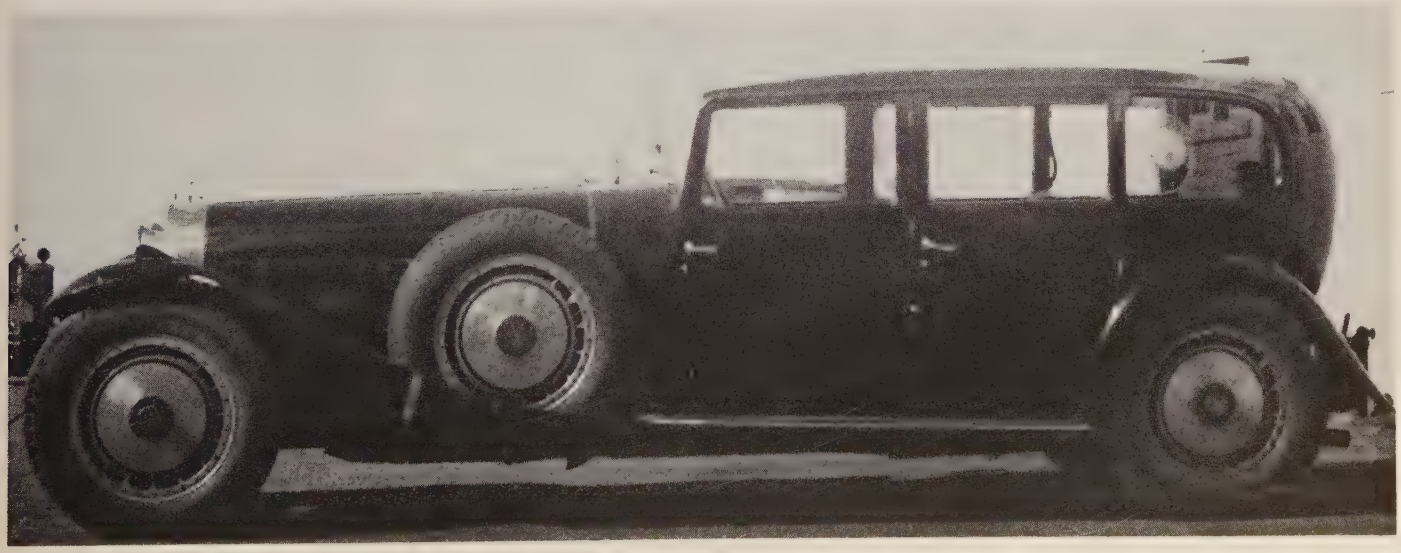
by Rick Van Weelden, M. E. '60

For something different in the way of personal transportation, a $40,000 Bugatti Royale is unequaled. This was the observation of John W. Shakespeare, a foreign car dealer who lives in Centralia. He therefore decided to purchase one of these automotive behemoths. The fact that there are only six Royales in existence failed to dull Shakespeare's enthusiasm, and finally, after three years of persistant negotiation he was the new owner of a 1933 black limousene that had belonged to J. Lemon Burton of London, England.

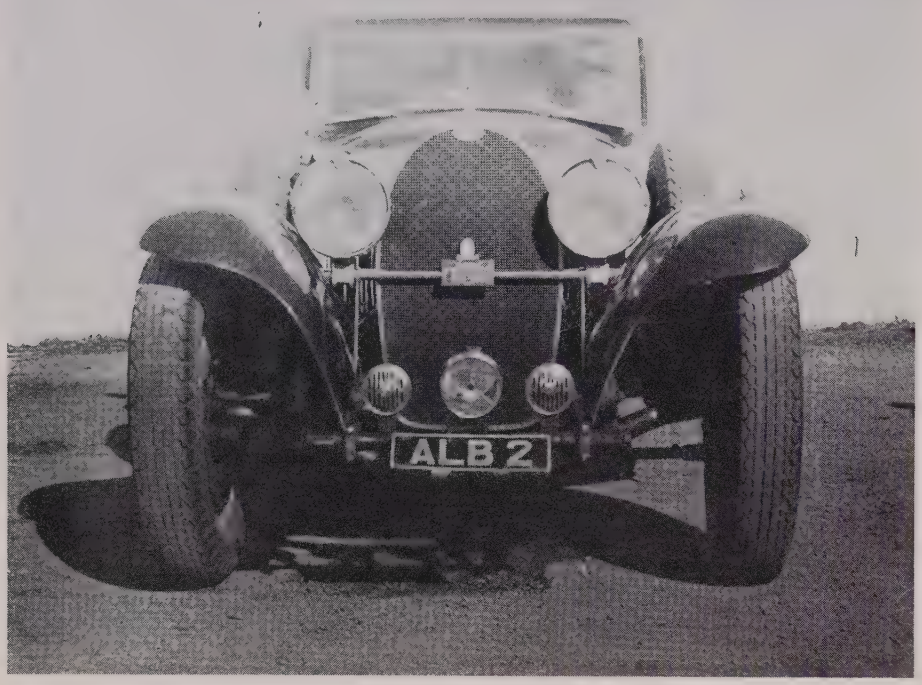
The car was put in a 3,000 pound crate and shipped to Chicago, where it arrived about three months ago. There the car was uncrated and filled with gasoline, oil, and water. A quarter turn of the crankshaft started the engine, and the car was driven to Champaign on the first leg of an exhibition tour. At present the car is at the Hoopeston branch of Shakespeare Motors. The Bugatti Royale, or "Golden Bug", is one of the largest cars ever built. It has an overall length of nineteen feet. When the bumpers are added it will be twenty two feet long. The wheelbase is fourteen feet two inches, equal to the total length of many cars. From the hood ornament to the windshield measures exactly seven feet. The tires on this car are $7{:}20 \times 24$ on a five foot, three inch tread. Naturally, a car this big is no lightweight: even though the body and many other parts of the car are made of aluminum, the weight still totals about 7,000 pounds.

Looking under the hood at the 300 horsepower engine we are again struck by the oversized dimensions of everything. It is certain that Ettore Bugatti seriously took the advice of the classic era motto: "design every part large enough so that it will not be strained in any way, then double the dimensions". For instance, consider the engine. It is a straight-eight design, consisting in part of a 238 pound cast iron block that is four feet, eight inches long, holding a 220 pound crankshaft that runs in nine water-cooled main bearings. Add on the other parts, and you have a 770 pound engine that delivers its maximum power at only 1,700 revolutions per minute.

If nothing else, Ettore Bugatti was an individualist. He knew little and cared less about the way other cars were designed and constructed. For instance, the single overhead camshaft activated one inlet and two exhaust valves per cylinder, which was contrary to contemporary practice. Also, Bugatti disliked detachable cylinder heads, so he designed his cylinder heads integral with the engine block. Many people felt that this was more trouble than it was worth, as it converted the ordinarily simple job of grinding the valves into engine disassembly job in-



TWENTY-TWO FEET long, all Bugatti Royale.



HEAD-ON VIEW OF THE BUGATTI Royale as a hapless pedestrian might visualize it.

volving removal of most of the internal parts, just so the valves can be removed from the engine.However, this fact did not bother Bugatti.

Many other unique features are in evidence. Notice, for example, the large distributor which feeds two spark plugs per cylinder. Then take a look at the carburetor. It is a double barrel updraft, designed, of course, by Bugatti. The top rod controls the air intake, while the other three are hand operated mixture controls: one for idling, and the other two individually controlling the crusing range output of each barrel.

Internally, the design is based on the constant velocity principle. Most carburetors mix the gasoline with the air first, and then regulate the volume with a butterfly valve. The constant velocity carburetor, however, regulates the respective volumes of gasoline before they reach the venturi, thus maintaining a constant velocity of air through it. Proponents of this system claim that it results in more efficient mixing of the gasoline and air over a wider volumetric deliverance range.

The carburetor is fed from a divided gasoline tank that holds 36 gallons in the main section, plus six gallons in reserve. With a full tank, therefore, it could travel over 590 miles, as the car averages fourteen miles per gallon in town, and slightly better on the highway. This is somewhat amazing, considering the car's size and weight.

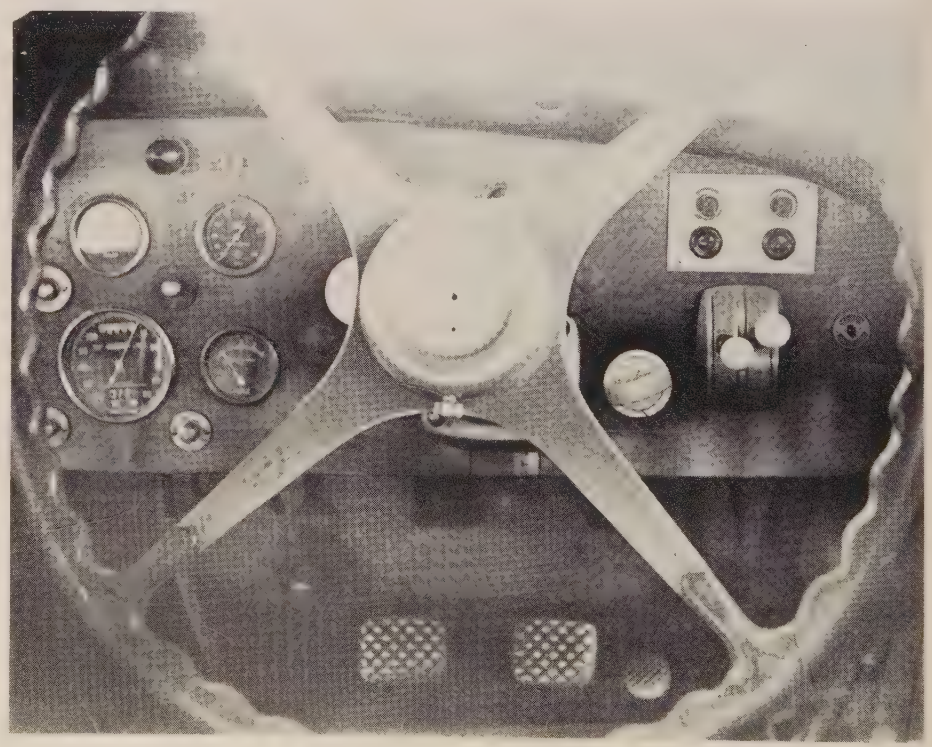
The engine is lubricated by five gallons of oil, as compared to five quarts average, using the dry sump system. With this system the oil does not stay in the oil pan underneath the engine, but is pumped out to a separate oil tank, and from there back to the engine. The cooling system holds fifteen gallons of water, which is circulated by a hefty centrifugal pump. Incidentally, the packing in this pump is the only thing on the car that has to be replaced. Aside from that, and a case of unbalanced front wheels, the car is in good running order.

The power transmission system is quite different from what we are used to. On our cars, the engine, flywheel, clutch, and transmission are all together. Not so in the Golden Bug. In this car, the engine is by itself. A short shaft runs from it to the light flywheel and the clutch, encased in alumnium under the front seat. From there another shaft goes back to the transmission and differential at the rear of the car.

The transmission is nonsynchromeshed, and in combination with the differential gives the following overall ratios: 7.5:1 (first), 3.6:1 (direct), 2.66:1 (overdrive), and 10:1 (reverse). Direct drive is used for most driving. Due to the tremendous amount of torque available, low gear is used only for starting on a steep upgrade, and other similar situations. Overdrive, on the other hand, is used only above 60 miles per hour.

This arrangement allows one to slow down to a dead-smooth three miles per hour if desired. If the transmission is put in overdrive, and the engine speed brought up to 1,000 revolutions per minute, usually considered just a fast idle, the car will be going 72 miles per hour. Top speed of the car is about 125 miles per hour.

Still other features of the car include the frame, which is made of



DASHBOARD SHOWS MANY complex gadgets including stopwatch found in the Royale.

I-beam girders that are ten inches high at the center of the car. Another point is the design of the brakes. They are eighteen inches in diameter by three and three-quarter inches wide. Like all but the last Bugatti brakes, they were cable-operated affairs requiring a lot of pedal pressure for activation. However, anyone strong enough to operate the brakes can be sure that the car will always stop, for the brakes are virtually fade-proof.

The body of this particular Royale was built by Park Ward of England. It was the only limousine body that was put on a Royale chassis. The interior boasts several interesting appointments. For example, there is a telephone between the chauffeur's seat and the rear compartment. Also, there is a radio installed in the right rear armrest. Up front, the steering wheel has a combination clock and stop-watch in its center, and a horn button under the rim at the intersection of each spoke.

The Royale chassis sold for $30,000 in 1933 money, with the body costing another ten thousand or so. Included in the price was a lifetime service and overhaul guarantee, and a gift of a hood ornament in the shape of a white elephant.

Ettore Bugatti, or "Le Patron" as he was called, was an intense Italian who spent most of his life in France. He was by nature artistic, temperamental, and, as we have seen, highly individualistic. He lived on his own medieval manor near Molsheim which raised or made almost everything it needed. His factory, along with his vineyards, stables, art and coach museums, farmland, hotel, racetrack, and other necessities of life was right on the premises. His life span lasted from 1882 to 1947.

Bugatti's total output was about 9,500 cars of some 70-odd different designs. Although he built cars from 1909 to 1939, he was at his best from the mid-twenties on. He was primarily a builder of sport and racing cars, and he achieved his greatest glory in the two years of 1926 and 1927, when his cars sped to victory 1045 times.

One evening at dinner an Englishwoman was seated next to Bugatti. She happened to remark, "Of course, M. Bugatti, everyone knows you make the best racing cars and the best road cars in the world; but for a town carriage of genuine elegance, one must still go to Rolls-Royce."

The next morning found Bugatti at the drafting tables creating "La Royale," which he was determined to have known as the biggest, most luxurious, most elegant car in the world, regardless of cost. The first one was built that year, but was subsequently wrecked. The other six were built between then and 1933. If nothing else, though, these cars demonstrate one thing: never underestimate the power of a woman.

(We are very grateful to Mr. Loyd Barton and Mr. Frank Cipelle, managers of the Hoopeston and Champaign branches of Shakespeare Motors, respectively, for assisting us in obtaining pictures of and information about the car.)

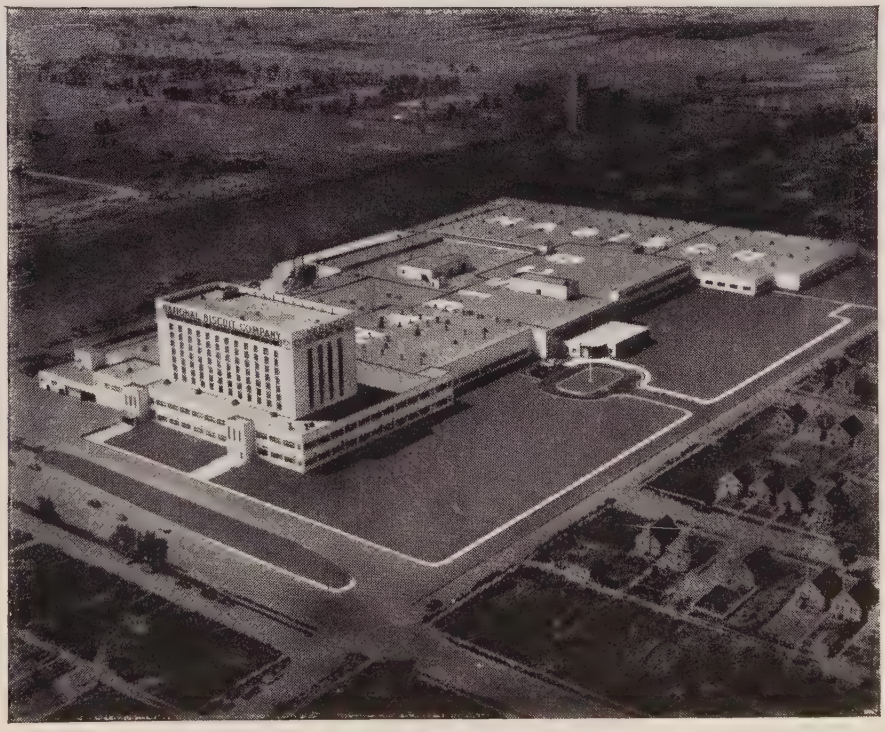
More Zuider Zee Reclaimed

In their constant struggle against the North Sea for more land, the Dutch scored another victory in September when 200 more square miles of the Zuider Zee were blocked off. In time, 1,000 new farms will rise in the reclaimed area, *Engineering News-Record* says. Reclaimed land from the Zuider Zee represents about one-eighth of the total Netherlands.

More Suburbia, More Roads

Suburban growth will require construction of 10,000 miles of new roads during the next 20 years, reports *Construction Methods and Equipment.* To serve expanding residential areas, the yearly needs will average approximately 374 miles of local streets and 125 miles of arterial traffic ways that connect with major highways.

STEAM AND THE WORLD'S LARGEST BAKERY



This new boiler plant at Nabisco's huge Chicago bakery was planned to provide, efficiently and economically, the steam that the bakery must have on tap at all times for heat, hot water and various processing operations.

Because the reliability, efficiency and economy of its steam source are so vital to this world-famous company, they selected B&W boilers.

Think a moment of most companies' use of steam—and its cost. Take a fast turn around a boiler plant. Spend a little time chatting—perhaps quite profitably—with engineers. Get the facts on a company's invested steam dollars in relation to the return they're getting. If the facts add up to problems, B&W engineers can and will help industrial companies and their consulting engineers solve these problems.

When a B&W boiler is chosen, long-range performance is assured. And isn't that what the buyer really wants? Not the boiler but its end product, the steam, and the assurance of an efficient, dependable, economical steam source. The service records of thousands of B&W boilers, in thousands of large, small and medium sized industrial and utility plants, supply that assurance.

The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

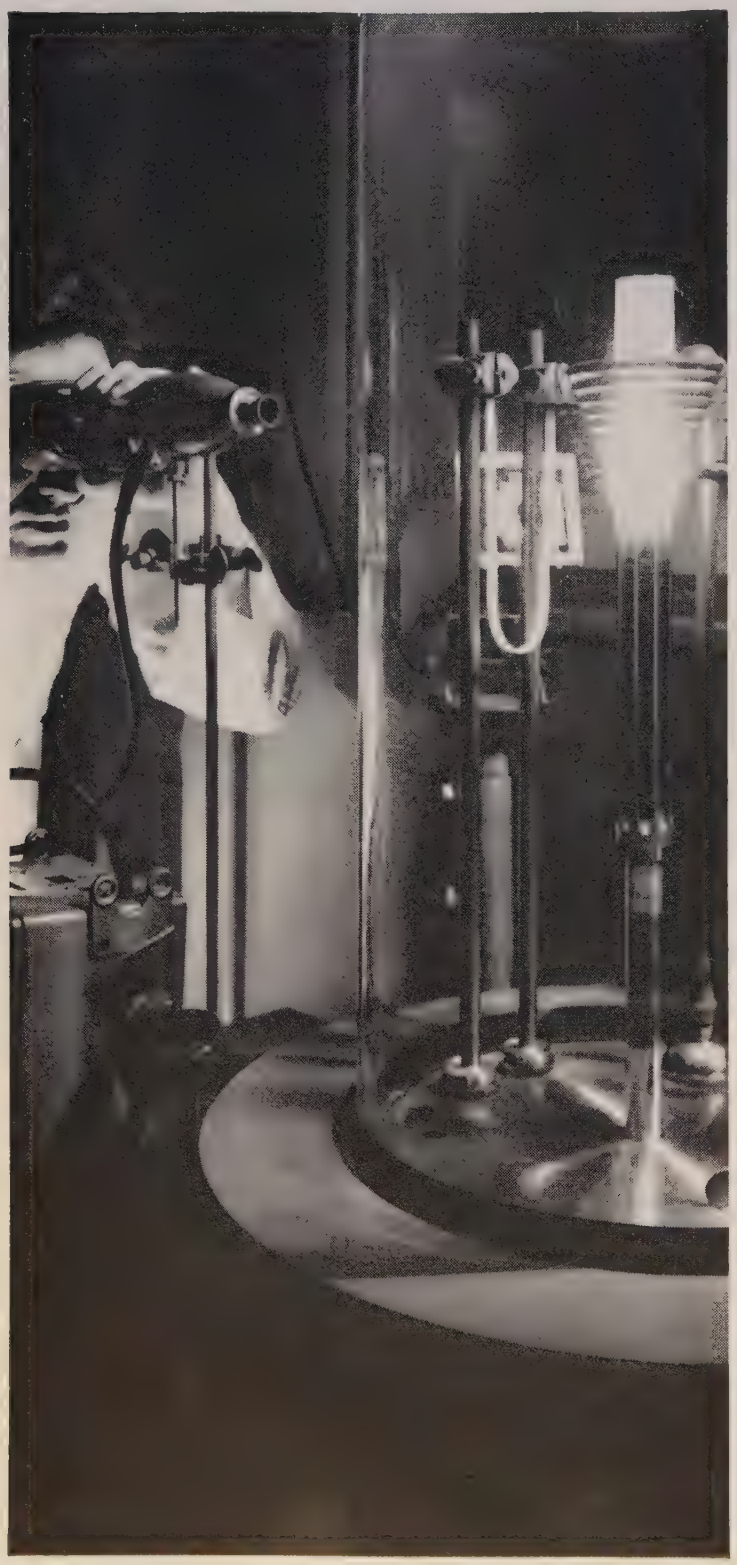
BABCOCK & WILCOX

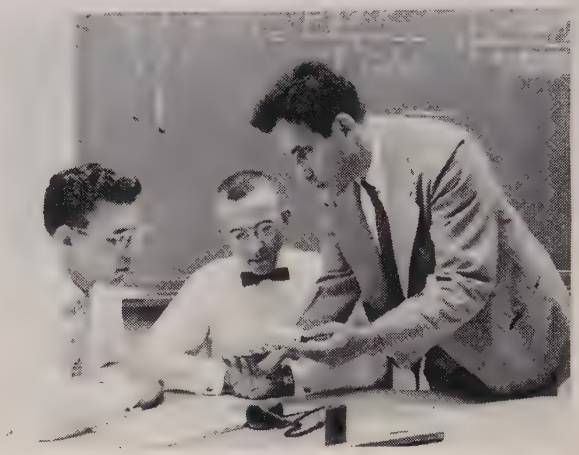
BOILER DIVISION

N-213

Refining metals to perfection

...A PROBLEM IN PURITY





ENGINEERS AT WESTINGHOUSE FACE CREATIVE CHALLENGES LIKE THIS EVERY DAY

Preparing superpure titanium and other hard-to-get metals was a tough problem, but Westinghouse scientists solved it. Their method, called cage-zone refining, uses an unusual method to melt a bar of metal while the metal acts as its own crucible, preventing contamination by a container.

Westinghouse offers you the opportunity to work on similar stimulating, challenging projects. Investigate career opportunities at Westinghouse, where the big expansion program means real chance for growth and progress for Electrical, Mechanical, Chemical or Industrial Engineers, Physicists, Mathematicians and Metallurgists.

In this one diversified company, you can do the kind of work you prefer . . . in the field of your choice—radar, decision devices, automation, electronics or nuclear energy. There's plenty of room at Westinghouse to move around—and up!

Million-dollar Educational Center offers a complete training program, and Master's and Ph.D. degrees can be earned at company cost at 22 colleges and universities.

Have your placement officer make a date for you now with the Westinghouse Interviewer, who will be on campus soon. Meanwhile, write for *Finding Your Place in Industry*, and *Continued Education in Westinghouse.*

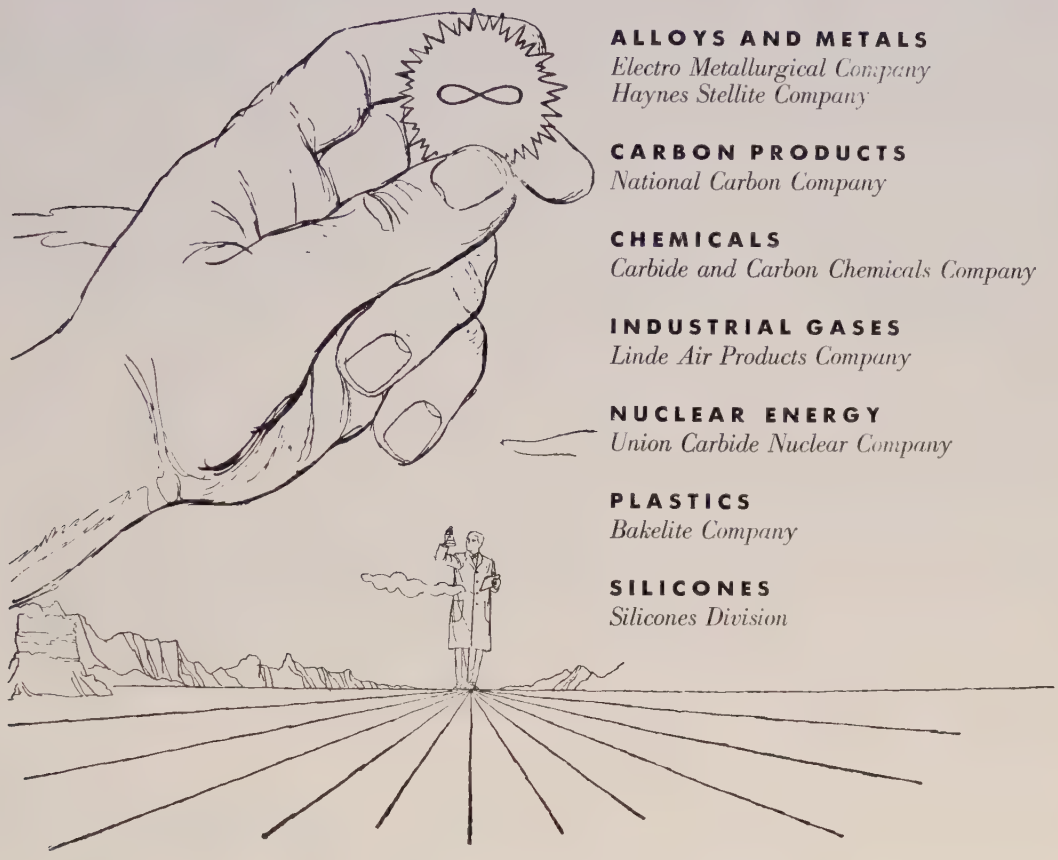
Write: Mr. C. W. Mills, Regional Educational Co-ordinator, Westinghouse Electric Corporation, Merchandise Mart Plaza, Chicago 90, Ill.

G-10300

Westinghouse

THE HORIZONS ARE UNLIMITED

for college graduates at UNION CARBIDE



ALLOYS AND METALS
Electro Metallurgical Company
Haynes Stellite Company

CARBON PRODUCTS
National Carbon Company

CHEMICALS
Carbide and Carbon Chemicals Company

INDUSTRIAL GASES
Linde Air Products Company

NUCLEAR ENERGY
Union Carbide Nuclear Company

PLASTICS
Bakelite Company

SILICONES
Silicones Division

Union Carbide offers to college graduates opportunities in some of the most rapidly expanding fields in industry. In all these fields the Divisions of Union Carbide need engineers, chemists, physicists, and business and liberal arts graduates.
For more information write
Co-ordinator of College Recruiting.

UNION CARBIDE
AND CARBON CORPORATION
30 East 42nd St. UCC New York 17, N. Y.

VTOL Aircraft

by Fred Breuer, Aero E. '57

Summary

This report has been prepared to investigate the VTOL aircraft and the present status of its development.

The primary problem is the provision of sufficient vertical thrust. Several methods of providing this thrust are under test and include propeller-flap configurations, propeller-tilt wing combinations, and turbojet installations.

Once satisfactory thrust is established, stability and control must be provided. This requirement poses a new problem since conventional aerodynamic control surfaces are inoperative at the reduced air speeds associated with VTOL. A partial solution has been obtained by using differential flap deflection and propeller pitch. Additional control effects are needed and, at present, jet reaction at the tail seems to be a promising answer to the problem.

In sufficient tests have been performed on which to base performance and range characteristics, but all sources seem to agree that VTOL airplanes can be built at the present state-of-the-art with a useful degree of performance.

Introduction

The concept of vertical take off and landing frees the airplane from the requirements of runways and will make every sizable clearing a potential operating point. In addition, a plane equipped for VTOL can as easily be adapted to shipboard use—both military and commercial.

Many problems present themselves as VTOL is considered, among them the provision of sufficient thrust, the direction of this thrust along a verticle axis, and the stabilization and control of the plane in hovering and transition flight.

Lift Systems

All that is required to produce VTOL is to impart a sufficient downward acceleration to a sufficient mass of air.

A sufficient downward acceleration requires providing thrust slightly exceeding the weight of the aircraft. A thrust/weight ratio of 1.03 has been established as satisfactory.

Several means have been proposed to provide this thrust. The most efficient static thrust producer is the helicopter rotor, but this aircraft will not be included in this study. The other lift systems, in order of their efficiency, are propellers (with and without shrouds), ducted fan engines and turbojets.

The propeller, without shrouds, can be used as a vertical lift device either with flap configurations or with tilt wing designs.

The propeller and flap combination uses a turbine or piston driven propeller with a flap system comprising 30 to 60 per cent of the wing chord, see Figure 1. This combination gives a resultant force rotated up to 70° from the horizontal. This 70° rotation of the thrust vector is achieved with only a 10 per cent loss of thrust. A full 90 per cent rotation of the force is not necessary, since the 70° turning is sufficient when combined with a 20° nose-up attitude of the plane. The biggest disadvantage of the propeller-flap combination is the downward pitching moment caused by the extreme flap deflection. This has been overcome by lowering the thrust axis so that the rotated thrust vector passes through the airplane center of gravity. Another suggestion for overcoming the downward pitching moment is the addition of a large leading edge slat, which provides a counteracting pitching moment.

Take off is effected with full flap deflection and after altitude is gained, the transition to forward flight is achieved by slowly retracting the flaps until the wing carries the plane in normal flight. The reverse of this is used in making an approach and vertical landing.

In the propeller-tilt wing arrangement there is no problem in rotating the thrust axis to a vertical position. The tilt wing design gives desirable hovering performance with a low vibration level. In addition, it possesses superior flight, stability and control characteristics. These arise since the tilt wing is a conventional airfoil without the adverse effects of any oversize flaps.

The addition of a shroud adds 25 per cent to the static thrust of a fixed diameter propeller with a fixed power input. Therefore, high static thrust is obtained with low fuel consuption.

As a result, the ducted propeller has been proposed for VTOL by Bell Aircraft Corporation. Their proposal uses wing tip mounted power plants with provision for 100° rotation of the thrust axis. With this plan, the wing would remain in its normal attitude through all stages of flight. For take off the shrouds are rotated 90° into a vertical position. Then as altitude is gained, the engines would be rotated slowly forward, the horizontal component of the propellers providing the forward thrust. The extreme 100° position would be used to decelerate the plane and unload the wing prior to vertical decent.

In all the proposed propeller VTOL designs, interconnecting shafting is planned between the engines so that failure of any one engine would not cause unbalanced forces.

Bell Aircraft Corp. has begun tests with a modified light plane with two Fairchild J44 jet engines, one mounted under each wing, with provision for ro-

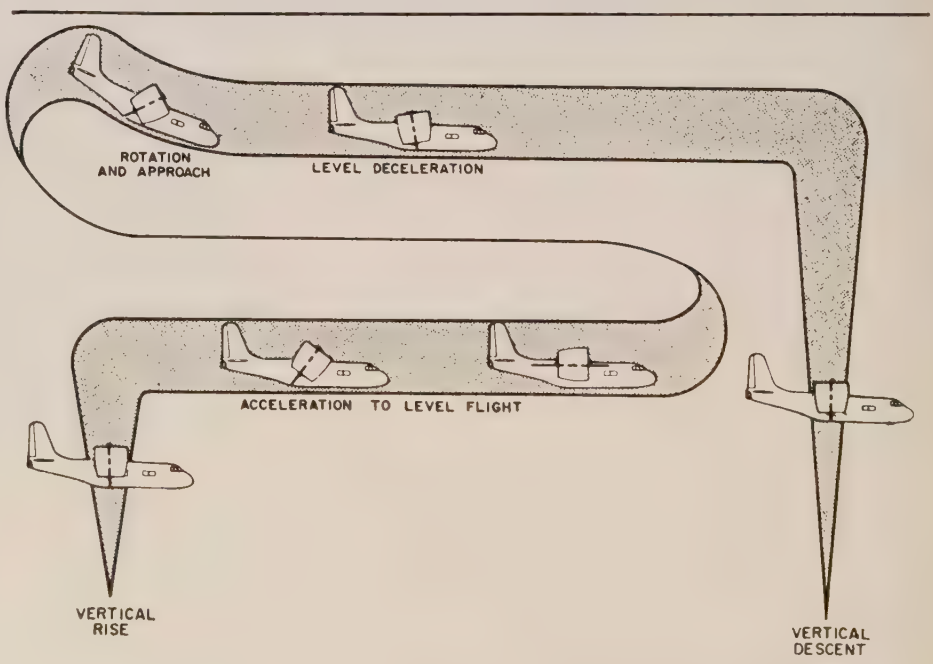


FIG. 3. VERTICAL TAKE-OFF and landing (rotated ducted propellers). (Charts from Aero Engineering Review and Aero Digest)

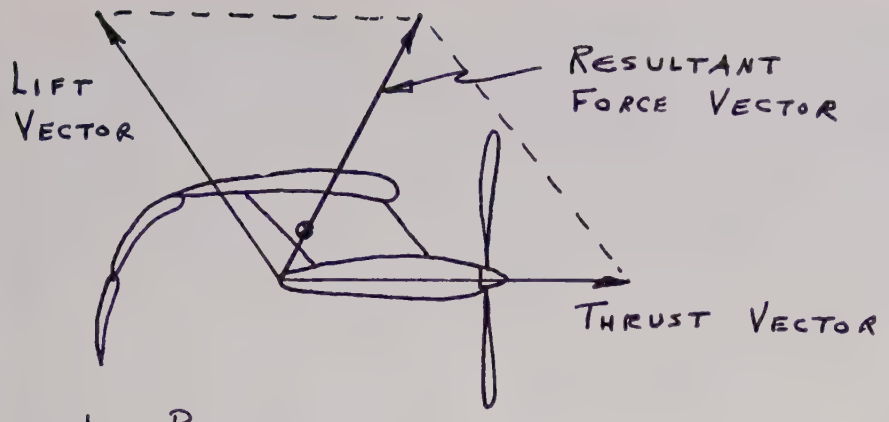


FIG 1. PROPELLER-FLAP CONFIGURATION

tating the engines. Ground effects were expected from the concentrated jet blast but it was found the exhaust spread out thinly over the ground and offered no problems other than extreme heating of the take off spot. The plane, however, was influenced by engine gyroscopic effects. After altitude was gained, the transition to forward flight was made by nosing the plane down slightly to gain forward speed and then slowly rotating the engines to a horizontal position. The turbojet was found to have excessive fuel consumption when hovering. This was expected since the turbojet is known to be an inefficient producer of static thrust.

Rolls Royce has performed jet VTOL tests in their flying thrust measuring rig aptly termed the "flying bedstead." Two Nene jet engines were used. One discharged through a center hole while the other discharged through two holes, one on either side of the center hole, thus minimizing the dangers associated with an engine failure. Gyroscopic effects were cancelled by rotating the engines in opposite directions. The engines were mounted horizontally with the jet blasts directed downward, although vertical turbojets are planned. Forward motion was given by increasing the rear nozzle opening, thus causing a slight nose-down attitude. The results gained from the "Flying Bedstead" prompted Rolls Royce to suggest auxiliary turbojets or rockets located in the fuselage for VTOL abilities and orthodox engine wing configurations for level flight. The weight of the auxiliary engines is estimated by Rolls Royce to be less than the extra weight involved in designing a wing and undercarriage for VTOL.

A radically different design has resulted from a joint French-German effort and is called the coleopter.

Their plan proposes an annular wing configuration with power provided by a turbojet or turboprop engine with the possibility of additional ramjet thrust, see Figure 2. The annular wing increases the power plant efficiency by the ducted fan principle, since it acts as a throat around the center part of the plane. A feature of this design is the structural rigidity offered by the annular wing. This increased rigidity is accomplished with an actual saving in weight over that of a conventional VTOL aircraft. The annular wing has no wing tip flow with the result that induced drag is one-half that of an elliptical wing with the same aspect ratio and lift coefficient. A model of the coleopter has been tested and, from the results, predictions were made that the coleopter can attain a vertical Mach number of 1 and a level flight Mach number of 2.

Stability and Control

New problems are being experienced in maintaining stable, controlled flight with VTOL aircraft. Most of them stem from the fact that the aerodynamic surfaces of the plane are moving so slowly during take off and hovering that they are virtually ineffective. Therefore, other means of control must be devised.

In the case of the propeller flap configuration, roll control was effected by differential propeller pitch in hovering and by differential flap deflection in transition. Yaw control was achieved by use of the flaps during hovering and with propeller pitch during transition. It was found that this control reversal introduced no real problem as it was a gradual change. The most serious problem faced in transition flight was the nose-up moment resulting from the low thrust axis. As previously stated, the thrust axis had to be lowered to prevent nose-down moment at take off. The problem was even more serious since the elevators were not yet effective due to the slow air speed.

The most promising relief of this conditon has been the proposal to use jet reaction at the tail. This could be provided by bleeding air from the turboprop engine and piping it to the tail or by using individual small turbojets mounted at the tail.

Another trouble spot with the propeller-flap combination is the severe upwash at the tail resulting from ground effects on the deflected slipstream. Most of this effect can be corrected by incorporating a slight negative incidence into the tail surfaces.

The propeller-tilt wing combination used differential propeller pitch for roll control in take off. Little trouble was encountered with yaw in take off since the tilt wing design has no deflected slipstream to create yawing forces. In transition, both differential propeller pitch and normal wing control surfaces were used to correct for roll and yaw.

Bell found that their jet VTOL test craft was neutral during hovering but that control was hampered because of engine gyroscopic effects. Because of this, transition was begun by nosing down the entire plane a few degrees rather than by rotating the engines. Engine rotation was then undertaken after the regular airfoils became effective. Further control is needed in transition and possibly can be obtained by jet reaction at the tail. This jet will likely bled from lifting jets and piped to variable deflecting nozzles located on the tail.

(Continued on Page 52)

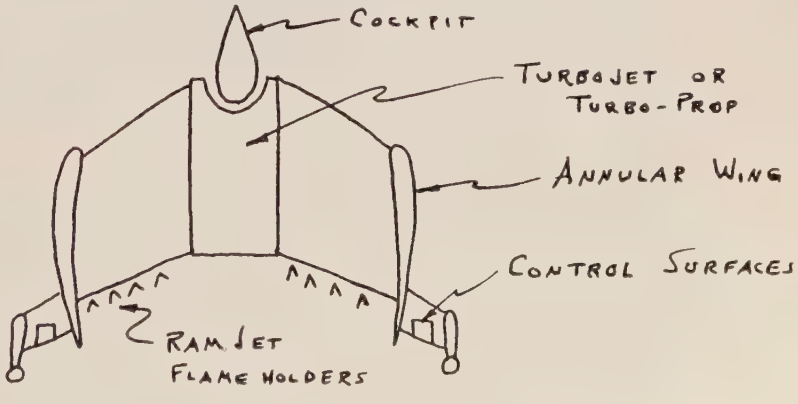


FIG 2. CROSS-SECTION OF THE COLEOPTER

Here's how graduate engineers move up in the GAS industry ... the nation's sixth largest

The Gas industry—the sixth largest in the nation—has a total investment of over $15 billion. Last year the industry set a new all-time record in number of customers, volume of gas sold, and dollar revenue. In fact, Gas contributed 25% of the total energy needs of the nation as compared with 11.3% in 1940. The Gas industry is a major force in the growth development and economic health of this country.

There are many opportunities for you in the Gas industry. The industry needs engineers, and does not overhire. You won't be regimented. There's always room for advancement. With utility companies and with manufacturers of Gas equipment, there's a future for you as an engineer. Call your nearest Gas Utility. They'll be glad to talk with you about your opportunity in the Gas industry.

American Gas Association.

Charles C. Ingram, Jr. became Vice President of Oklahoma Natural Gas Company in less than 15 years

Charles C. Ingram, Jr.
B.S. in Petroleum Engineering, 1940
University of Oklahoma

Charles Ingram has been Vice President of the Land and Geological Department of Oklahoma Natural Gas Company since June of 1955. Mr. Ingram joined the company immediately after his graduation from Oklahoma, and was soon called into service. Following his discharge, 5 years later, he rejoined the Engineering Department in Tulsa. He was quickly promoted to Assistant Chief Engineer and then took over the position of Superintendent of Gas Purchase and Reserves, and by 1954 was District Superintendent of the Oklahoma City district.

After 6 years with Lone Star Gas, Bill Collins took over a new job in a new field for the company

William A. Collins, Jr
B.S. in Mechanical Engineering, 1947
A & M College of Texas

Bill Collins is employed by the Lone Star Gas Company in Dallas as Coordinator of Air Conditioning and Utilization. Bill operates over 400 square miles in North Texas and Southern Oklahoma. Since joining Lone Star, Bill has worked primarily in the design, sales and installation of air conditioning equipment, with some time devoted to industrial gas applications. When it was found that a large scale air conditioning program requires close attention to design and installation as well as sales and service policies, a special department was organized in 1955. Bill was put in charge.

E.E.'s, M.E.'s, A.E.'s, Math, Physics & Chemistry Majors:

APL announces openings for young men of exceptional talent

The Applied Physics Laboratory (APL) of The Johns Hopkins University, one of the country's leading R & D organizations, offers a unique opportunity for young men of exceptional talent because it is directed solely by technical men and scientists, and it has a single objective: technical progress.

Because of its predominantly professional nature, and the high calibre of its staff members, APL has been able to consistently maintain its reputation as an R & D pioneer. APL developed the first proximity fuze, the first supersonic ramjet engine, and the Navy's Bumblebee family of missiles, which includes TERRIER, TALOS and TARTAR.

Location & Facilities

The APL laboratories, covering over 350,000 square feet, are located in rolling countryside midway between Washington, D. C. and Baltimore, and in Silver Spring, Md. The facilities of APL combined with those of its 21 associate and subcontractors and Government test stations provide exceptional opportunities for its staff members to develop and extend their capabilities.

A strong program of financial assistance for graduate study is offered. Salaries at APL compare favorably with those of industrial R & D organizations. Young men of talent and higher-than-average grades are invited to inquire about staff opportunities. All inquiries will be answered in detail. Contact your Placement Officer or write:

PROFESSIONAL STAFF APPOINTMENTS

The Johns Hopkins University
Applied Physics Laboratory

8621 GEORGIA AVENUE, SILVER SPRING, MD.

(Continued from Page 49)

Performance and Range

Few actual quantities are available for performance and range characteristics since VTOL aircraft are still in the test model stage. However, sufficient information has been gathered from the tests to predict these values (with some degree of accuracy) for a hypothetical VTOL transport airplane. Mostof the projected estimates center on a propeller VTOL aircraft with a gross weight of 40,000 to 60,000 lbs. and a payload of 5,000 to 19,000 lbs. Maximum speed expectations average about 450 mph with a cruise capability of 300 to 350 mph. Ranges for this hypothetical design are expected to go as high as 1,800 miles with a minimum of time spent in hovering. These performance values were quoted on a basis of an altitude in the 20,000 to 40,000 ft. range. No predictions were found for performance characteristics of a jet VTOL aircraft.

Conclusion

This study has pointed out in a broad and general manner the progress that has been made to date with VTOL airplanes. Test models utilizing all the various lift systems have been flown with varying degrees of success. More work has been done with the propeller as a lifting device than with the turbojet since the former provides more static thrust than does the turbojet.

In all cases, the main problem encountered was that of stability and control during take off, hovering and transition. Additional experimental work is being conducted to learn more about these conditions so that design modifications can overcome and control their effects.

All sources of information were in agreement on one point—VTOL airplanes can be built at the present state-of-the-art with a useful degree of performance.

REFERENCES

1. "New Vertiplane Has Conventional Look," W. J. Coughlin, *Aviation Week,* 24 Oct. 55, p. 38.

2. "An Application of the Ducted Propeller to a VTOL Transport Airplane," James A. O'Malley, Jr., *Aero Eng. Review,* Aug. 56, pp. 52-56.

3. "Problems in the Design of Propeller Driven Vertical Take Off Transport Airplanes," M. O. McKinney, R. E. Kuhn, and J. B. Hammock, *Aero Eng. Review,* Apr. 56, pp. 68-75.

4. "Propeller - Lifted Tilt - Wing VTOL Aircraft," Joseph Stuart III, *Aero Eng. Review,* Aug. 56, pp. 49-52.

5. "Design Aspects of Bell Aircraft VTOL Airplane," J. A. O'Malley, *Engineering,* 179:737, 10 June 55.

6. "Jet Lift," *Flight,* v 67, n 2402, 4 Feb. 55, pp. 134-135.

7. "Coleopter—World's Most Radical Aircraft," E. Bergaust, *Aero Digest,* v 70, n 6, June 55, pp. 22-25.

Campus Personalities . . .

DR. E. C. JORDAN

by Don Snedeker, E. E. '58

We often hear the rumor that the College of Engineering at the University may switch to a five-year program for engineering students. This month we interviewed Prof. E. C. Jordan, head of the Electrical Engineering Department, to obtain his opinions concerning the possibility. In view of the fact that he was on the faculty at Ohio State University when that school switched to the five-year program in engineering, we believed that his thoughts on the matter might hold considerable interest. Also we had in mind to make the engineering student better acquainted with one of the key members of our faculty.

Prof. Jordan indicated that there was not much chance of the College of Engineering going over to five years of study for the bachelor's degree, at least in the near future. He said that the pressures for such a change are great, however. Each year there are many new advances in the field of science, and each new advance in turn gives the engineering student something new to study. This increasing study load would point toward adding an additional year to the engineering program.

At the same time, there is an increasing desire to make engineering more of a profession, rather than a mere technical training. This trend in engineering education calls for more courses in the so-called "humanities." Prof. Jordan points out that we do have certain requirements in this field which have to be met before graduation, and that every curriculum has non-technical electives which the engineering student may use in the liberal arts field. It is up to the student to make the most intelligent use of these electives.

The factors favoring the retention of a four year program appear to be time and money. It is often difficult enough for the engineering student to secure the necessary finances for even four years of college. We can easily see what an additional year would mean along these lines. Joining in very closely with this factor is the element of time. Many students are married after several years of college and many more still have several years of service to look forward to. An extra year of college for the bachelor's degree in science might detour some of these individuals into another field at a time when we need so many engineers.

In conclusion, Prof. Jordan said he believes that four years is sufficient time to study for a bachelor's degree. The fifth year of study should be restricted to those students most capable of advanced work, and with this additional year they should be eligible for the master's degree.

Many of Prof. Jordan's thoughts are probably influenced by his experiences at Ohio State University. At OSU, he taught for four years, from 1941 to 1945, first as an instructor and then as an assistant professor. While he was teaching there, OSU switched over to a five year engineering program. Prof. Jordan served on the committee whose responsibility was to replan the program of studies over the span of five years. Since that time he has had many opportunities to talk with individuals who were affected by this change.

Edward C. Jordan was born on the last day of the year, Dec. 31, 1910. His place of birth was Edmonton, Alberta, Canada, which he points out is the new oil capital of North America.

He received his secondary training in Edmonton, finishing up at Victoria High School. From there, he continued on to the University of Alberta where he earned his bachelor's and master's degrees in Electrical Engineering. While at the University of Alberta, he worked as an engineer at the University radio station which was formed in 1928. Radio communication was still in its infancy in those days and Jordan developed an intense interest in the propagation of radio waves which showed up a few years later.

Upon graduation from the University of Alberta in 1935, he went to work for International Nickel in Ontario, producers of 90% of the world's supply of nickel. Several years here and Prof. Jordan came to the turning point in his life when he decided to continue ad-

DR. E. C. JORDAN directs the activities of the Electrical Engineering Department from his desk in 156 E. E. Building.

physics
chemistry
metallurgy
these 6 fields of scientific research are a challenge...
electronics
engineering
mathematics
...to superior engineers and scientists interested in participating in the development of the Atomic Age.
In addition to its continuing and ever-expanding achievement in nuclear weapons research, the Laboratory is now pioneering in the fascinating fields of nuclear power and nuclear propulsion.
At the Laboratory, staff members have the opportunity of associating with leaders in theoretical and experimental research ... of working with some of the Western World's finest equipment and facilities ... of winning recognition ... of achieving advancement commensurate with ability.
If you would like more information about the Laboratory's career opportunities, about the delightful climate and area in which Los Alamos is located, write to:
DEPARTMENT OF
SCIENTIFIC PERSONNEL
Division 5612
los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

vanced study in communications and radio engineering. With this purpose in mind, he entered OSU in 1937 and did his doctorate research in the field of electromagnetic radiation. Using accoustic models of radio antennas he radiated sound waves and measured their intensity with a microphone. From the analogy of sound waves to electromagnetic radiation he was able to apply his results to radio antennas. Prof. Jordan was the third person to complete his doctorate in Electrical Engineering at OSU.

Upon completing his advanced study, he decided to try teaching as a career. This is one decision he says he has never regretted. Although the monetary rewards may be less than in industry, there is great satisfaction in being able to help engineering students develop to the full extent of their capabilities. Embarking on his teaching career, Dr. Jordan went to Massachusetts for one year to teach at Worcester Polytechnic Institute. From there he returned to OSU where he taught for four years. While at OSU he also served as consultant for the radio antenna laboratory.

In 1945, Dr. Jordan left OSU to accept the position of associate professor at UI, and has been here ever since. He confesses to enjoying his instructing period here very much, especially since he was able to continue his research in radio antennas. During the war he had worked on aircraft antenna design and at the UI he continued in the field of directional radio antennas. This was climaxed in 1954 by his appointment to his present job, head of the Electrical Engineering Department.

Aside from his work, Dr. Jordan tells us he keeps in shape by playing handball as often as possible, and occasionally he tries to get a game of golf into his busy schedule. He is a member of the American Institute of Electrical Engineers, fellow of the Institute of Radio Engineers, member of the American Society for Engineering Education, member of Eta Kappa Nu, Tau Beta Pi and others too numerous to mention.

At present, Dr. Jordan is National Chairman of Commission 6B on the United States of America Committee of the International Radio Union. This radio union meets every two years to discuss international problems concerning radio transmission. In this capacity, Prof. Jordan traveled to Zurich, Switzerland in 1950 and to The Hague, Holland, in 1954.

By the end of the interview, Prof. Jordan was again speaking of the many rewards in the field of teaching and the ever-increasing need for more teachers, especially in the field of science. It is certainly something to think about when we consider the case in point, Prof. Edward C. Jordan.

Put yourself in this picture at Wagner

Graduate engineers move *up* at Wagner.

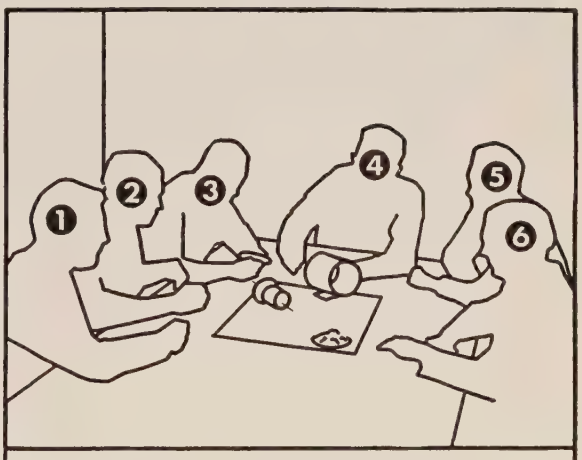
The Wagner Electric Corporation, St. Louis' largest manufacturer of products for the rapidly advancing Electrical and Automotive industries, is engineering-minded. Since 1891, when the company was established by two enterprising engineers, engineering has been the backbone of its development.

Many of the top executive and the key management positions are occupied by men who began their careers with the company immediately following graduation from engineering colleges. Our President is a graduate of Pennsylvania State University; Vice President in charge of Engineering, Manufacturing and Industrial Relations—Ohio State University; Vice President in charge of Sales and Service—University of Illinois; Controller—Washington University; Executive Engineer—Purdue University; Electrical Sales Manager—University of Illinois. The men shown in the photograph above are typical of the many engineering graduates who occupy key positions at Wagner.

At Wagner, the engineer receives outstanding training in the area of his own special interest and ability—whether product engineering, manufacturing, or sales.

To see how *you* fit in the Wagner picture—sign up with your college placement officer, or write to the Wagner Industrial Relations Division *today*.

Wagner Electric Corporation
ST. LOUIS 14, MO.
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS, AIR AND HYDRAULIC



These men all started with Wagner as graduate engineers. They are: **1.** Joe Hepp, Manager, Patent, Metallurgical & Chemical Division, Missouri School of Mines & Metallurgy, 1948. **2.** Charles Herron, Foreman, Motor Manufacturing Division, University of Cincinnati, 1953. **3.** Jack Dudley, Chief Inspector, Iowa State College, 1951. **4.** Carl Widell, Director of Research & Development, Purdue University, 1940. **5.** Hollis Sisk, Motor Development Supervisor, Iowa State College, 1947. **6.** Carl Anderson, Assistant Sales Manager, University of Missouri, 1941.

G56-3

DEATH OF AN ENGINEER (?)

by Dan Cohen, Journ. '58

The following story is perhaps a first for Technograph, a piece of fiction. It's not science fiction, it's more of a fantasy, dealing with an engineering student. It was written by a non-engineering student especially for Technograph readers. Any resemblance to persons living or dead is definitely coincidental.

Whatever you thought of Oliver, and most people didn't think much of him at all, you had to admit he was persistent. He could be accurately called stupid, clumsy, mean, square and a great many other things but his overshadowing trait was his persistence.

For years all of Oliver's energies had been directed toward one goal—avoiding work, or more particularly, avoiding work in his father's taffy factory. The old man treasured the idea that some day his son would "get in there and pull for old Hamilton taffy," as he put it. But the mere thought of such made Oliver violently sick.

When, shortly after Oliver's high school graduation, his father first mentioned the idea of work in the taffy factory, Oliver screamed and shouted that he was being robbed of the chance for a college education.

Oliver's father was somewhat surprised at his son's desire for higher learning. He remembered the long impassioned speeches against compulsory education. He also recalled that the high school principal had claimed that Oliver's diploma was the result of a clerical error.

But he was not one to stand in the way of his son's apparent desire for greater intellectual pursuits, so he sent Oliver to college. And Oliver flunked out. So he changed schools, and flunked out again. This time he changed curriculums, and still he flunked out. So he changed schools again, and of course flunked out again.

And so it went year after year, from school to school, from curriculum to curriculum, Oliver just couldn't seem to make the grade. Finally he reached the end of the line; he was 31 years old, had been in college for 11 years and was still a first semester sophomore. By this time his father had become finally and fully fed up with the situation.

Oliver was sternly warned that if he did not become a second semester sophomore this time it was the taffy factory or skid row for him.

At the moment Oliver was enrolled as an engineering student in a large Midwestern university. This was not because he liked engineering, or liked large Midwestern universities for that matter, it was merely because he had exhausted all other possibilities.

With less than a month left in the semester Oliver began to realize that things were going to be no better this time than they had been before, and the stomach wrenching spectacle of the taffy factory darkened his horizons.

Now completely desperate, Oliver turned to desperate measures. He hatched plots to bribe, intimidate, or if necessary assassinate his professors, but his success was only moderate. He invented hundreds of ingenious ponies which could fool the most eagle-eyed observer, only to find that they were all too small to contain all the things he didn't know about engineering. He made an unsuccessful attempt to have plastic surgery done on a particularly brilliant classmate of his so that he would have someone to take tests for him.

One day he snuck into his room, his arms full of stolen exams, only to find out that even if he knew the questions he still didn't know the answers. And above and beyond all this activity, Oliver even tried studying, but the stuff just wouldn't stick.

By this time most ordinary persons would have decided that things were hopeless and would have swallowed a mouthful of broken glass to end it all. But in this respect Oliver was no ordinary person.

With all other possibilities exhausted, Oliver turned to magic. He haunted dark corners of old bookshops poring over yellowed copies of occult books. He visited gypsy fortune tellers, Hindu swamis and stage magicians. He sent away for pamphlets on the secret power of the ancients that he found advertised in the back of cheap magazines.

From biological supply houses, epicurian restaurants and junk yards he collected a sickening variety of animal, vegetable and mineral things to be used in the making of potions and the casting of spells. His room began to look like a place where the stage props for Macbeth are kept, and it began to smell like . . . well, it began to smell.

People began to think Oliver was crazy, and you could hardly blame them. Sometimes Oliver would go to class wearing a dried toad on a string around his neck, or sometimes he would sit in the back of a lecture sticking pins in a dummy dressed up to look like his instructor. Or there was the time he ran around the physics lab waving a branch of wolfbane and shouting a series of unintelligible words.

But even all these Herculean efforts were doomed to failure. Oliver tried and tried but nothing worked, and then one night about two weeks before finals . . .

Oliver had just finished reading a mildewed old text about summoning up demons from the underworld. The correct figures had been drawn on the floor and the correct powder had been mixed. He said the correct words, tossed the powder into the figure and Poof!

It wasn't at all the way Oliver had expected it. No cloud of smoke, no sulphur and brimstone smell, no flames. And the demon was most undemonlike. He looked almost human aside from his horns, fangs, pointed ears and three foot tail. Not only human but very continental to boot. He wore neatly pressed grey flannels, a natty tweed jacket and had a silk scarf knotted carelessly around his neck.

After all these weeks of failure Oliver was a bit surprised by success, and this kind of success was even more surprising.

"Well I'll be damned," he said.

"Undoubtedly," said the demon.

The demon struck a casual pose as Oliver examined him from all sides to make sure that he was really there.

"I'm Oliver Hamilton," he said finally, "And you're Mr. . . ."

The demon gave a bored sigh. "Reedeebub. And now that you've seen me and talked to me, you can run out and tell all your friends that you've seen a real live demon. Now how about sending me back; I was in the middle of some very important business."

"Oh no," cried Oliver, "I want you to help me."

"Go suck an egg, sonny."

Oliver became frantic. After so many failures he was not going to let this one get away. "The book says you have to help me. I summoned you and I'm

your master and you have to do what I say."

Reedeebub scowled. "I thought they burned all those lousy books along with their owners. Look, sonny, I was in the middle of a big card game. I had a jack high straight flush in diamonds, and I knew that ghoul across the table was bluffing. There were 13 souls in the pot and I was ready to rake 'em in when bam you pull me into this crumby room.

"I'm sorry," whimpered Oliver, "but I really need help."

Reedeebub now assumed a paternal tone of voice. "Now see here sonny, you don't really want my help. You ought to know that help from a demon never really does anyone any good. Believe me kid you'll be better off without it. And besides if I get back real quick I might still be able to collect those 13 souls."

Now over the initial shock of success Oliver became more daring. "No, I have no where else to turn, you have to help me."

"What fools these mortals be," sighed the demon.

"I'm not very good in school you see, and if I don't pass all my courses this semester I'll have to go back to work in my father's taffy factory, and I hate taffy."

"Don't tell me your little troubles, sonny."

"You see I want you to help me get through school."

"Why don't guys like you salt your food with rat poison?"

"Will you help me?" Oliver pleaded.

Reedeebub scowled more deeply. "I'll help you, I have to help you, but you don't how how much trouble it will mean to me, and you don't how how little good it will do you. But I'll help you."

"No tricks now."

"Don't worry I'll help you."

"How? What will you do for me."

"Don't worry I'll help you."

And then Reedeebub was gone. Oliver tried to summon him back but it did no good. But somewhere he thought he heard a faint chuckle and the rustle of cards being shuffled.

The next two weeks were the most frantic of Oliver's life. He was convinced that the demon would not help him. In fact he began to doubt that he ever saw the demon, and for a while to doubt his own sanity.

But persistent to the end he had redoubled his magical efforts, with no success.

If Oliver had a tail he would certainly have had it between his legs when he entered his first final. He was mentally and physically exhausted. He had spent the entire night dancing nude under the full moon in a last desperate attempt to get help from the great spirit. But it seemed as though the spirit was out to lunch.

Now there was no hope, nothing but the taffy factory. Oliver could not understand why he even bothered to go to this test. He knew nothing about math, but he went anyhow.

As the professor handed Oliver his test he had a smirk on his face. He was going to enjoy marking this one.

Oliver looked at his test. Of course he knew nothing. It could have been written in sanskrit and he wouldn't have known the difference.

Then suddenly, he knew the answers to all the questions, he still didn't understand the questions but he knew all the answers. And in the back of his mind he heard the faint rustle of cards and the whispered words, "What fools these mortals be."

Oliver wrote and wrote, formulas flowed from him as easily as excuses and when he handed in a filled booklet an hour before anyone else finished the tests he knew it was perfect, and it was he who had the smirk on his face.

So it went with all the rest of his tests. They were all perfect. The professors were astonished, they were sure that he was cheating but they just could not figure out how! And though it broke their hearts and offended their sense of justice they gave him good grades.

Oliver was overjoyed, and so was his father, and he was allowed to continue another semester, and another and another and another. And his work was always perfect.

They couldn't believe it, no one especially Oliver could know that much. But he did, or at least he seemed to.

So after years of being bounced around from school to school, Oliver settled down and became the leader of his class, in everything, and was graduated with the highest honors.

Oliver was the top engineering student in his school and perhaps in the country and different companies broke their necks offering him bigger and better jobs with bigger and better salaries. Oliver of course took the biggest and best.

Now it was a job and it meant work, but the way things came to him Oliver figured it would be almost like not working, and with all the money involved it would be so much better than school.

Shortly after getting his job Oliver was set to work on a project. He listened to the instructions about the project and didn't understand a thing his boss was saying but that didn't bother him, he knew it would come to him.

He looked at the blueprints and they were nothing more than a mass of white lines on blue paper to him, but still he didn't worry he knew it would come to him.

"Mr. Hamilton," said his boss pointing to the blueprints, "I'd like you to frim those framajams." Well that isn't what the boss actually said but that's what it sounded like to Oliver.

He looked back at the blueprints, and they still meant nothing. It would come, he knew it would come. But it didn't.

Oliver lasted two days on that job and when the company fired him they were mad because they thought he was just malingering. They didn't believe that a person who had done to well in school couldn't do a simple think like frimming framajams.

Despite the bad reference Oliver found it easy to get a second high paying job. The third, however, was almost impossible to get, and there was no fourth.

In his room one evening, Oliver beat his hands and finally his head on the wall. "Why don't the answers come to me," he wailed. They always did before, why not now?"

And in the back of his mind he heard the faint shuffling of cards and the whispered words, "You only asked me to help you through school sonny, and this isn't school."

Oliver collapsed into a chair. "Reedeebub, so that was it. why wasn't I more careful when I asked him to help me."

Oliver found another hitch in Reedeebub's help when he went back to school. It seems that as far as the demon was concerned his obligation did not extend into graduate school.

Now there was nothing, nothing but the taffy factory. "No!" thought Oliver, not the taffy factory, nothing could be worse than that crumby taffy factory." There was one other alternative. Oliver poured a handful of sleeping pills out of the bottle and swallowed them all.

"Anything but the taffy factory," he gasped.

* * *

When Oliver awoke, and he was rather surprised that he awoke, he found that he was no longer in bed, but laying on a large flat surface. He tried to get up but couldn't, he could only turn his head from side to side.

He turned his head to the right and looked up. There towering above him was a huge unmistakable figure. Still dressed in his natty tweed jacket with the silk scarf was Reedeebub. A little farther away to the left was a hideous green creature. Both the creature and Reedeebub were holding cards.

Suddenly Reedeebub's huge hand reached down and pushed Oliver roughly toward the center of the table where several other figures were lying.

"Raise you one," said Reedeebub.

AVIATION

owes this veteran furnace a deep bow

From this very furnace (and its fellows) came the special heat-resistant steels for aircraft engine exhaust valves that first let men fly an ocean: Lindbergh, Chamberlain, Byrd. From it and its successors in various A-L mills came the high-temperature alloys that made possible the first aircraft superchargers . . . and later, the first ventures into jet and rocket-propelled flight. ● In your future business life, whenever *you* have a problem of resisting heat, corrosion, wear, or great stress—or of satisfying special electrical requirements—remember to see us about it, won't you? ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WSW 6302

PIONEERING on the Horizons of Steel

Allegheny Ludlum

AL
LEADING PRODUCER
HIGH-ALLOY STEELS

IGY Space Project . . .

Launching the Satellite

by Phil Philhower, Aero E. '60

On July 1, 1957, the International Geophysical Year will be launched. This "year," to run from July 1957, through December 1958, will mark the greatest joint effort ever made by scientists from all over the world to learn more about the mysteries of the universe. Scientists from 40 nations will combine efforts in many fields to make this historic event successful.

The history of this event is relatively simple. In the year 1883, a unified effort of international experts gave birth to the "First International Polar Year." As a result of these efforts, much was learned about meteorology, geo-magnatism, and the Aurora Borealis. In 1932-33, the Second International Polar year was marked. This time, as before, it was used mainly for arctic studies. Due to technological advances, however, it was possible to include in this year, studies of the ionosphere by the use of radio.

This, the third in the series, will be the biggest and most comprehensive yet attempted. It will comprise many phases being ardently studied by men expert in their respective fields. The scope of geophysics is amazingly broad. It includes geodesy, seismology, hydrology, techonophysics, vulvanology, and oceanography, all of which involve the earth's crust and interior. Geophysics also includes meteorology, climatology, glaciology, geomagnetism, and geoelectricity. Physics of the mesophere, ionosphere, and Aurora are also integral parts of the program.

The procedure followed in pursuing these various fields of study will be of unlimited scope and unvarying perseverance. Of the many projects planned for this "year," the most spectacular is already on the drawing boards. It involves the surmounting of an obstacle that not too many years ago seemed insurmountable.

President Eisenhower's press secretary, James C. Hagerty, broke the news to the general public on July 29, 1955 when he read this statement: ". . . on behalf of the President, I am now announcing that the President has approved plans by this country for going ahead with the launching of small, unmanned, earth circling satellites as part of the U. S. participation in the International Geophysical Year. This program will, for the first time in history, enable scientists throughout the world to make sustained observations in the regions beyond the earth's atmosphere."

Indeed, this was an historic statement. Since that time, much has been done toward the realization of this long range planning. The tentative specifications of the satellite, its components, capabilities, limitations, and launching have already been drawn up. Contracts have been let for the multi-phase operation of putting the satellite into it's orbit.

The satellite, as it is conceived now will be a small sphere, 21 inches in diameter. The interior of the "moon" will be a maze of equipment especially designed to tell the scientists on earth everything that it "sees" during its flight through space. All power sources and telemetering equipment inside will be sealed in a vacuum to protect them from harm due to unknown

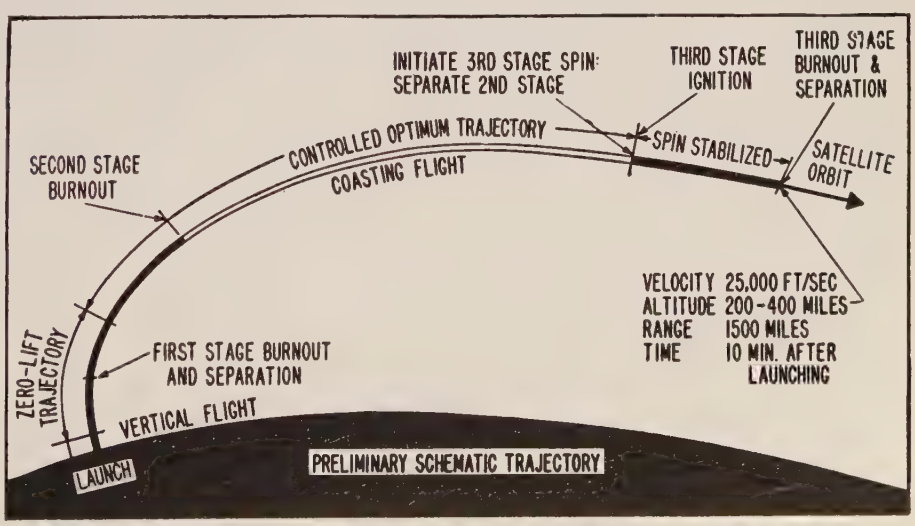
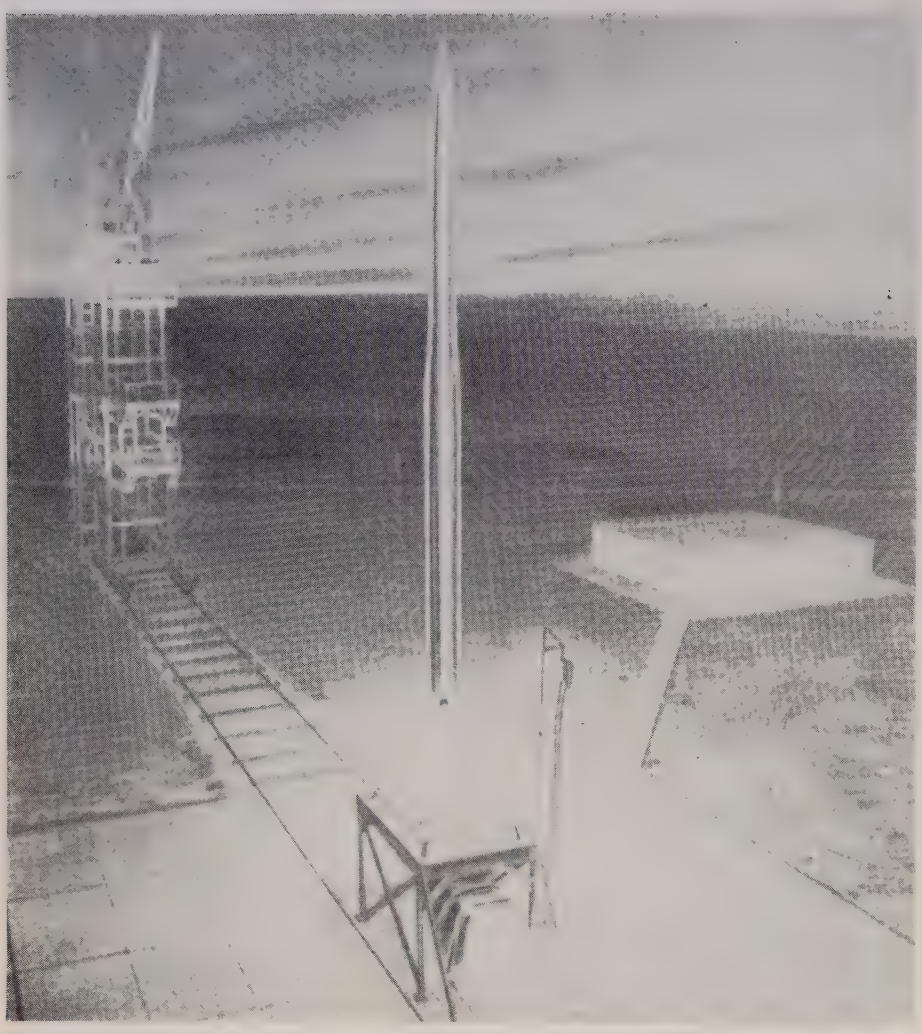


CHART SHOWS THE PATH to be followed by the satellite just after take-off. (Photo and chart from Aviation Week)



ARTIST'S CONCEPTION OF satellite launching platform.

atmospheric conditions. The spheroid will also contain an external well or wells to house equipment which must be exposed to the atmosphere.

The weight of the satellite is of maximum importance. For every pound of added weight, the satellite's speed will be reduced by 80 ft./sec. Because of this big weight problem much discussion and experimentation has gone into the choosing of the protective skin surface of the satellite. The issue is so complex, that it has not as yet been decided, however, scientists have developed the argument to this point: They now favor a compromise of either aluminum or magnesium, combined with either an aluminum oxide or silicone oxide coating. These materials were chosen because it was felt that they would afford the best strength/weight ratio.

Another factor, which only serves to complicate the already huge design problems is the problem of aerodynamic heating. *(Technograph, May, '56).* If the shell of the satellite is not made to withstand the effects of friction, it will literally melt and render the whole project a failure. This problem is treated in a following paragraph.

The satellite will be launched by a three-stage rocket, capale of projecting the satellbite into its orbit 300 miles above the earth's surface at a velocity of 18,000 miles per hour.

Project Vanguard, as the project is called, is being engineered by the Navy, and the Martin Aircraft Co., of Baltimore, Md. The Martin Co. is in charge of getting the satellite out to its orbit 300 miles above the earth's surface. Two separate subcontracts have been let for the design of the third stage of the launching rocket in an attempt to achieve the highest degree of perfection in the least amount of time. The actual satellite will be constructed at the Naval Research lab under the direction of Homer E. Newell.

Martin has designed a three stage rocket, similar to the Viking, which will carry the "moon" to its orbit. Its size permits its launching from a conventional launching platform. Figure 1 shows an artist's view of the three stage, 72 foot rocket as it leaves the platform. It will have a maximum base diameter of 45" and weigh 11 tons. This combination gives it a high fineness ratio of 19:1.

The vehicle will be finless with guidance equipment located in both the first and second stages. Scientists will have absolutely no positive control over the rocket after the second and third stages have separated. When they separate, a longitudinal spin will be imparted to the third stage, thereby keeping it on its course.

The entire assembly, high as a six story building, and scarcely four feet wide at its base, will be launched vertically. The first stage, burning 7-8 tons of liquid oxygen, ethyl alcohol, gasoline, and silicone oil, and developing 27,000 pounds thrust, will provide about 15 per cent of the orbital velocity and most of the energy necessary to raise the last two stages to orbital altitude. After 2 minutes and 20 seconds, it will burn out at an altitude of 36 miles. It will then return to earth at a distance of approximately 240 miles from its Patrick Air Force Base Florida launching site.

The second stage will then fire and take it on up to 140 miles and give it a velocity of 11,000 miles per hour. This stage will burn 1½ tons of unsymmetrical dimethyl hydrazine, and nitric acid under pressure of helium. Because the third stage is housed in the nose of the second, and the satellite is carried in the third, the second stage will accompany the other two more than half of the desired distance without powered propulsion. An array of jet reactors will provide complete control after burnout of the second stage as the last two stages coast up to orbital altitude. The second stage will provide 32 per cent of the orbital velocity.

The second stage nose cone covers the third stage to protect it and the satellite from the danger of aerodynamic heating. This cone will be jettisoned early during the second stage burning when lower air density reduces the danger due to aerodynamic heating.

As they part, the second stage must impart a rotation to the five foot third section, along its longitudinal axis. This is essential for third stage flight stability. The third stage will burn a solid fuel. This will be stored in a chamber in the third stage while en route to orbital position. This presents a danger to the satellite through heat soak from this solid fuel. Several corrective suggestions on the subject have so far produced no positive results.

When the third stage fires, the third stage-satellite system must be in orbit. An error of $\pm$ 1.5 degrees to the horizontal at this point will mean either a drastically reduced life of the satellite or the relocating of all the ground radio observation posts along the satellite's path. This point in the rocket's journey should be reached 100 minutes after initial launching.

Not until the satellite has finally been located in its orbit can its value be

measured nor its usefulness counted upon. If the orbit has an apogee (high point) of 1,400 miles, and a perigee (low point) of 200 miles, it will stay aloft long enough to accomplish its purpose. It has been pointed out that if it has a perigee of 300 miles it will probably last for a year. If it is only 200 miles, it can only be expected to function for 15 days. If the lower limit nears 100 miles, its life expectancy will be only one hour.

Other orbital difficulties will be encountered in various forms. Because of accumulated errors in sensing and stability during the first two stages, it will be impossible to place the satellite in a perfect circular orbit. To account for these errors, the final velocity of the third stage will be higher than that required for circular orbiting and will result in an elliptical path.

Another point as yet undecided is the question of separating the satellite and the third stage once orbiting has begun. This would be advisable for several reasons. First, it would provide two objects for visual observation. The burned out hulk of the third section, because of its higher mass, will descend to earth first. A comparative study of the descent times and rates may prove valuable.

Telemetering from the satellite would be better too, if the two sections were to be separated. The telemetering antenna may suffer "antenna nulls" if the two bodies are connected. Since the value of the experiment depends so heavily upon this telemetered data, it would seem that this factor alone would decide the issue.

In order for the satellite to fulfill its purpose, it must be tracked and be kept in contact with at all times. Minitrack, a system of radio triangulation, will be used to establish its position at any time. Because of the ever present weight problem, radio equipment must be kept very light. Although transistors would be of great advantage in this department, the old stand-by mercury cells will be employed. Their proven worthiness has made them acceptable despite the weight difference and the fact that their use necessitates that instrumentation can be operated only when passing a telemetering station.

The satellite transmitter will consist of a continuous wave oscillator operating at 108 megacycles. It will put out 10-50 milliwatts. The use of several minitrack installations will make it possible to establish the satellite's position within a fraction of a milliradian. These minitrack installations will be located on the 75th meridian.

The information will be telemetered back via pulse width modulation of an F. M. carrier in the regular 216-235 mc. telemetering band. This type was selected because the AFB from which the satellites will be launched is equipped to handle this PWM type telemtering.

The satellite will telemeter back to earth information on many fields of research. Many major research groups in the country are competing for a chance to have a satellite equipped to find data pertinent to its research. There have been six projects accepted thus far.

(1) A study on the percentage of the earth covered by clouds will be taken up for the Signal Corps Laboratories.

(2) Equipment will be installed to measure pressure and size of interplanetary dust and extreme ultraviolet radiation in the orbital area for the Air Force Combridge Research Center.

(3) The calculation of the electron density above the F layer region will be carried out for the Ballistic Research Lab. Aberdeen Proving Grounds.

(4) The University of Maryland will study meteoric erosion of the satellite.

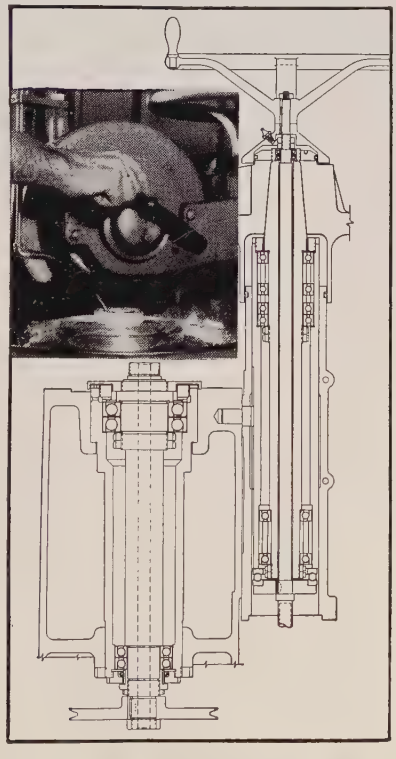
(5) The Naval Research Lab., builder of the satellite, will study intensity of solar and cosmic ray radiation, upper atmosphere heating effect on the satellite, and upper atmospheric pressure.

(6) The State University of Iowa will study the data brought back on the composition of primary radiation.

These six items are examples of what the satellite will do. It, or others like it, will undoubtedly do much more. The density of the earth's crust, geodetic measurements, and experiments on air density are but a few more of the numerous jobs of which the satellite will be capable. During the course of the 18 month "year" twelve satellites will be launched. Each will be launched with different specific purposes in mind.

The altitude of the orbit of the satellite will determine its visibility. If it is projected correctly into its orbit, it will circle the earth once every 1½ hours. It should be visible for 8-12 minutes as it streaks from horizon to horizon. It is expected that the orbit will cover a belt within 2,500 miles on either side of the equator. This will mean a fluctuation of ± 40 degrees latitude and may permit observation as far north as Columbus, Ohio.

When this satellite is completed and placed in its orbit, one of man's greatest ambitions will have been realized. For centuries man has wondered about the mysteries of space. Within the year, some of these questions will be answered. You must realize that this is only a start, but it is a huge step in the direction of unlimited technological advances.



FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

How a precision grinder holds its precision—for years

In pre-loading super-precision ball bearings, a precision surface grinder is used for close-tolerance grinding of bearing ring faces (see photo). In the grinder diagrammed here, moving parts are mounted on Fafnir ball bearings to assure the absolute rigidity essential for this exacting work.

All bearings indicated, except the thrust bearings at the bottom of the column supporting the wheelhead arm, are Fafnir pre-loaded, super-precision types. The oscillating wheelhead is similarly mounted. Original bearings in column and workhead have been in operation and have maintained their precision for over 15 years.

A long history of such successful bearing applications is a big reason why engineers throughout industry look to Fafnir for help with special bearing problems. The Fafnir Bearing Company, New Britain, Conn. (23 Branch Offices)

• • •

An interesting aspect of an engineering career with Fafnir is the opportunity for first-hand observation of Fafnir products actually on-the-job in Fafnir plants. Fafnir bearings are widely used in equipment necessary for bearing manufacture, including machines such as the precision surface grinder above.

The opportunity for on-the-job evaluation of bearing performance is invaluable as a source of information — and, often, inspiration — in the vital, diversified work of designing, developing, and assisting in the application of bearings for all of industry. Perhaps Fafnir offers you the challenges and satisfactions you want in engineering, or sales engineering. We'd be glad to hear from you.

"A new era is beginning...

"As I review the progress in aeronautics within so short a span, and marvel at the complex aircraft of today, I call it an achievement little short of miraculous.

"Today, electronically-guided planes take off and land without human touch. Lethal sky missiles seek and destroy invisible targets with uncanny precision. And still other fantastic achievements in both man-controlled and pilotless flight are now in the offing.

"When men go to the moon and planets, electronically-controlled skycraft will take them there. Aviation maps will be studded with stars as well as with cities. New developments in aeronautics will go on and on. Success opportunities and careers will continue to develop for ambitious young men in this exciting field where a new era is beginning."*

LEE De FOREST

Appropriately qualified to speak for aeronautics and other fields in which his own scientific achievements play an important part, Dr. Lee de Forest gives helpful counsel to young graduates headed for successful, rewarding careers.

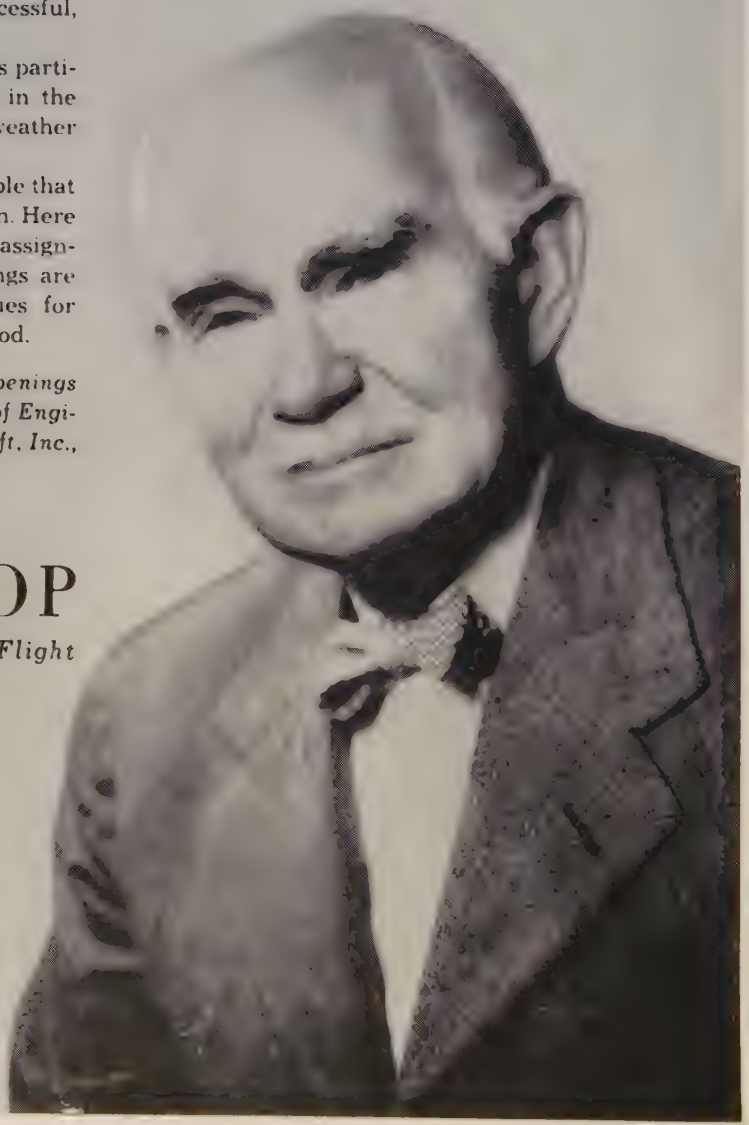
His expression, "a new era is beginning," has particular significance at Northrop, world leader in the design, development and production of all-weather and pilotless aircraft.

At Northrop, permanent positions are available that offer full play for individual talent and ambition. Here the graduate engineer will find interesting assignments for which he is best fitted. Surroundings are attractive, co-workers congenial, opportunities for advancement unceasing, the compensation good.

For detailed information regarding specific openings in your field of specialization, write Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., 1001 East Broadway, Hawthorne, California.

NORTHROP

Pioneers in All Weather and Pilotless Flight



*A statement by Dr. Lee de Forest, pioneer in radio.

New careers for engineers, now that

Color TV is here!

RCA's pioneering in this exciting medium means unlimited opportunities for you in every phase from laboratory to TV studio

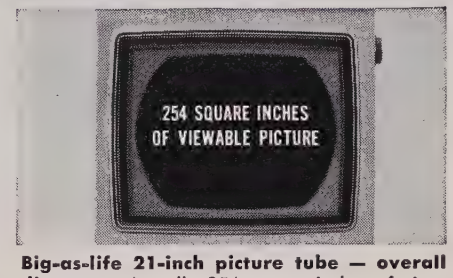
Now, more than ever, new engineering skills and techniques are needed in the television industry — to keep abreast of the tremendous strides being made in Color TV. RCA — world leader in electronics — invites young engineers to investigate these challenging opportunities. Only with RCA will you find a scientific climate particularly suited to the needs of young engineers. Your knowledge and imagination will be given full rein. Rewards are many.

Your talents are needed in research — in TV receiver design — in network operations — even "backstage" at TV studios. The experience and knowledge you gain can take you anywhere!

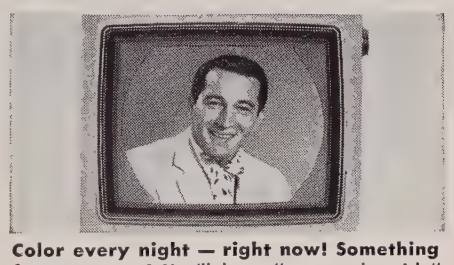
WHERE TO, MR. ENGINEER?

RCA offers careers in TV and allied fields — in research, development, design and manufacturing—for engineers with Bachelor or advanced degrees in E.E., M.E. or Physics. Join the RCA family. For full information write to: Mr. Robert Haklisch, Manager, College Relations, Radio Corporation of America, Camden 2, New Jersey.

Like 2 sets in 1—get Color and black-and-white shows, too! It's RCA Victor Compatible Color TV. See the great Color shows in "Living Color"—regular shows in crisp, clear black-and-white. With Big Color, you see *everything*.

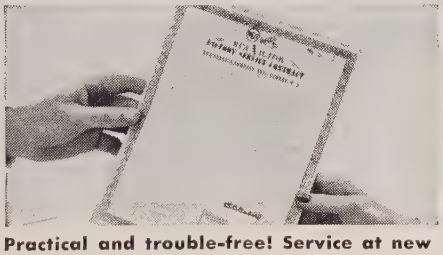


Big-as-life 21-inch picture tube — overall diameter. Actually 254 square inches of viewable picture area. And every inch a masterpiece of "Living Color." Here are the most natural tones you've ever seen—on a big-as-life screen!



Color every night — right now! Something for everyone! You'll have "two on the aisle" for the best shows ever—drama, comedies, Spectaculars, children's shows, local telecasts. For now 216 TV stations are equipped to telecast Color.

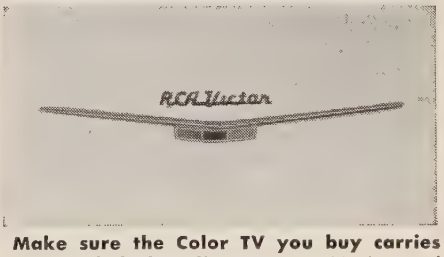
Big Color TV is so easy to tune, even a child can do it! Turn two color knobs and there's your Big Color picture! It's easy, quick, accurate. It's a new thrill when the picture pops onto the screen in glowing "Living Color."



Practical and trouble-free! Service at new low cost! Big Color is *dependable* Color. And RCA Victor Factory Service is available in most areas (but only to RCA Victor owners). $39.95 covers installation and service for ninety days.

Color TV is a common-sense investment—costs only a few cents a day. It's sure to become the standard in home entertainment for years to come—yet you can enjoy Color every night *right now!* And you can buy on easy budget terms.

Now starts at $495 — no more than once paid for black-and-white. This is the lowest price for Big Color TV in RCA Victor history! There are 10 stunning Big Color sets to choose from—table, consolette, lowboys, and consoles, too.



Make sure the Color TV you buy carries this symbol of quality. Because RCA pioneered and developed Compatible Color television, RCA Victor Big Color TV—like RCA Victor black-and-white—is First Choice in TV.

RCA®

RADIO CORPORATION OF AMERICA

ELECTRONICS FOR LIVING

BRAIN TEASERS

edited by Don Georgi, E. E. '59

(Back from a short absence is our popular brain-teasers column. We are pursuing a new policy in that answers will be printed next month rather than in the same issue as the problems. That will stop you from cheating.—*Editors)*

If you were at the base of the Empire State building, how would you be able to measure the height of said building, with the aid of a photoelectrometer and a timer?

How Many Cigarettes?

Five men are in a poker game: Brown, Perkins, Turner, Jones and Reilly. Their brands of cigarettes are Luckies, Camels, Kools, Old Golds and Chesterfields, but not necessarily in that order. At the beginning of the game, the number of cargarettes possessed by each of the players was 20, 15, 8, 6 and 3 but not necessarily in that order.

At a certain time during the game, when no one was smoking, the following conditions exist:

(1) Perkins asked for three cards.

(2) Reilly had smoked half of his original supply, or one less than Turner smoked.

(3) The Chesterfield man originally had as many more, plus half as many more, plus 2½ more cigarettes than he now has.

(4) The man who was drawing to an inside straight had absent-mindedly lit the tipped end of his fifth cigarette, the last one he smoked.

(5) The man who smokes Luckies had smoked at least two more than anyone else, including Perkins.

(6) Brown drew as many aces as he originally had cigarettes.

(7) No one had smoked all his cigarettes.

(8) The Camel man asks Jones to pass Brown's matches.

How many cigarettes did each man have to begin with, and what brand.

* * *

There was recently a sale of various articles of ladies' apparel on the second floor of a downtown department store. A young woman and her grandmother were rushing to get to the sale before the best of the bargains were all gone. They reached the foot of the escalator going from the first floor to the second floor at the same time and stepped on the first step together. Since they were both in a hurry to get to the sale, they did not stand still and ride the escalator up, but walked up, both at a constant rate, until they reached the top. The young lady forgot that her grandmother could not keep up with her, and walked as fast as she could. The older woman was only able to take one step for every three that her younger companion took. Of course, when the young woman reached the top she had to wait for her grandmother, so she didn't gain anything by her rushing. The granddaughter took 36 steps, her grandmother took 24 steps. How many steps were in sight at one time on the moving staircase?

* * *

A Church hymn board has four grooved rows on which the numbers of four hymns chosen for the service are placed: The hymn book in use contains 700 hymns. What is the smallest number of number plates, each carrying one digit, which must be kept in stock so that the numbers of any four different hymns selected can be displayed; and how will the result be affected if an inverted 6 can be used for a 9?

* * *

A man is going to make a trip of 27,000 miles. His tires are guaranteed for 12,000 miles each. What is the least number of tires that he must take (including the four tires on the car) in order to make the trip? Explain.

* * *

Once upon a time, there lived a rich farmer who had 30 children, 15 by his first wife, who was dead, and 15 by his second wife. The latter woman was eager that her eldest son should inherit the property. Accordingly one day, she said to him, "Dear Husband, you are getting too old. We ought to settle who shall be heir. Let us arrange our 30 children in a circle, and counting from one of them, remove every tenth child until there remains but one, who shall succeed to your estate."

Quite astonished was the old man, as the first fourteen children eliminated were by his first wife. Noticing this he realized that the odds were 15 to 1 that the latter wife's children would be chosen. "From this point on" the man suggested that they would count backward from the lone remaining child from deceased wife. Which became heir? What order did they start?

* * *

There are four kegs, all having small leaks. One fills a mug in hours; another fills the same mug in 3 hours; another in 4 hours; and the remaining keg fills the mug in ½ hour. If the liquid being lost from each keg is all funneled into the same mug, how long will it take to fill the mug?

* * *

I have no watch, but I have an excellent clock, which I occasionally forget to wind. Once when this happened I went to the house of a friend, passed the evening in listening to the radio concert program, and went back and set my clock. How could I do this without knowing beforehand the length of the trip.

* * *

A motor-driven hacksaw used to cut through cold-rolled steel in a shop bites 0.0085 inch deep into the metal at each stroke. The speed of the hacksaw is 120 strokes per minute.

The hacksaw is to be put to work cutting through a number of pieces of cold-rolled steel each three inches wide and two inches thick. How long will it take to cut through each piece?

* * *

A tree 60 ft. high breaks off 25 ft. from the ground and strikes 26 ft. up the slope. Find the slope of the ground.

Underwater Pipeline Record

Aworld's record for installation of a pipeline underwater was set by the Collins Construction Co., of Ft. Lavaca, Tex. *Construction Methods and Equipment* reports that 12 miles of 10¾-inch diameter concrete-coated steel pipe was laid in 80 hours across Corpus Christi Bay, Tex. The previous record was established in 1953 by the J. Ray McDermott Co. when it placed 10½ miles of 10¾-inch pipe in 14 days in Louisiana. The Collins Co. assembled 4,000 foot sections of pipe on the shore and winched the line across the bay, welding on each new section of the shoreline.

The Origin of

THE CO-OP PLAN

by Jon Grushka, E. E. '59

DEAN HERMAN SCHNEIDER (Photo from Cincinnati Co-op Engineer)

As most of you know, when a senior student in Education or Music leaves the University for an eight week session of practice teaching, he is doing so in order to find out exactly how he is going to fit in to the educational system, and to gain the needed experience of working with other instructors and pupils. I imagine that most of you at one time or another have had a practice teacher in your high school, and you noticed how he was practically "all thumbs" when it came to the simplest tasks of conducting a class for the first time. I remember one practice teacher at our high school who got very upset after finding out he had given us a quiz covering the wrong material. Things like this don't happen to just practice teachers and music instructors; they happen to all of us the minute we graduate from college. We will all have to go through some period of training after we graduate, to get us accustomed to the surroundings and the nature of our work, much as some of us may have had to go through a one or two week probationary period when starting out on a summer job. These practice teaching sessions are to help the graduating seniors be able to fit into place with the least amount of lost time.

For engineering students, this period can not only be long, but expensive as well. That is why many colleges and universities are now incorporating the Co-operative Engineering Plan — to help prepare graduating engineers for the work that lies ahead.

The Co-op Plan has now passed the mark of 50 years since its founding by the late Dean Herman Schneider, in 1906. Schneider had learned, from various employers in industry, that the graduating seniors in engineering from the different colleges and universities had all the technical knowledge available—from books—but to put it to actual use in their work after graduation was another story. There was a much too long "breaking-in" period in which the engineer would have to learn how to use this wealth of information within him. Schneider now pondered over the idea of how theoretical knowledge and practical knowledge could be coordinated, so as to make the graduating engineer more useful and profitable, both to himself and to industry.

TABLE 1

Calendar periods	Regular school terms	Co-op terms
Summer	Vacation	5th term
Fall	5th term	A
Spring	6th term	6th term
Summer	Vacation	B
Fall	7th term	7th term
Spring	8th term	C
Summer	Vacation	8th term
Fall	9th term	9th term
Spring	10th term	10th term

Then one evening the idea came to him! While walking across the campus of Lehigh University on his way home, Schneider was alarmed by the blast of a Bessemer converter at a steel mill adjacent to the university. "Why not?" he thought. Here, right next to one another, were a large university and a huge modern industry—an industry with the latest, most expensive equipment, which would soon become the industrial laboratory for his plan. Schneider's idea was to have some of these young men, who were studying engineering in Lehigh University, begin employment on a part-time basis while they were still in school, since most of them would eventually work here at these mills upon their graduation. This employment could also be recognized as part of their educational training.

Schneider related his idea to some of his colleagues, but received so many negative reactions from them, that he decided he would have to do much more research before he could convince anyone that the idea was sound. He wanted to find out more about the type of work that was to be done by the engineers, and what the qualifications for these jobs would be.

After much time and analysis, he found that the engineers who were most successful upon graduating from college were those who had done one of three things: (1) worked while attending college, either for meals or just spending money; (2) worked during the vacation period. (3) stayed out of college one or more terms in order to make more money in order to continue their studies. He believed this to be true since most of the students who had to earn all or part of their way through college would most likely be more serious about their studies. Schneider also believed that if the jobs could be directly related to the student's curriculum and to the type of work he would be doing upon completion of his studies, they could be made an important part of his training.

During the fall and winter months of 1901, Schneider spent most of his time outlining a special training program for engineers. He did not try further to get his plan adopted at Lehigh, and was doubtful as to whether he could get any one else interested in his plan at this time, since it would most likely disrupt a department that was already firmly established.

During the summer of 1902, Schneider offered his specific plan to the executives of a number of firms in the Pittsburgh area, all of whom were very impressed with his plan, but none of whom would put it into actual practice. Since there were no more possibilities in this area, Schneider decided it would be best to try a different section of the country with his plan. He was offered a position in the department of civil engineering at the University of Wisconsin, but another graduate of Lehigh, who was on the faculty staff at the University of Cincinnati, wanted to go to the University of Wisconsin to teach, so he and Schneider traded positions. Schneider then entered the University of Cincinnati as the new Assistant Professor of Civil Engineering. He introduced his plan once more; this time

WHY CERTAIN DESIGNS SUCCEED

an idea to help you advance faster

SUCCESSFUL designers state that costs are the most important factor in the success of any product development today. Manufacturers recognize this and, as a result, seek out the engineers who are cost minded.

Industry's stress on lower costs comes from the increasing competition for buyers. Rising costs of materials and labor must be offset by good designs to keep selling prices down to realize a profit from sales.

Ingenious use of materials is the best way you can eliminate needless expense in manufacture. By using steel as the basic material and welding for fabrication, you have a decided advantage in saving money for a manufacturing company . . . and getting your designs accepted.

Cast Construction — Costs $28.13

Welded Steel Construction — Costs $6.49

Results from using welded steel instead of gray iron are shown in the above design comparison of a typical bracket used on modern machinery. The cast bracket costs $28.13. The welded steel bracket costs $6.49, weighs 65% less, yet is stronger and more rigid than the cast design.

Similar savings are possible in many types of mechanical parts. Therefore, it will pay you to know how to utilize steel. Why not write us for latest design bulletins.

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
The World's Largest Manufacturer of Arc Welding Equipment

to the new president of the University of Cincinnati, Dr. Charles Dabney, in 1904.

By 1906, the university's Board of Directors was ready to embark on a new plan of engineering education, following Schneider's plan. At the start of the plan, the engineering students were divided into two groups—one of which would be working in industry, and the other studying at school. In this first trial of the Co-op Plan, the students would alternate between job and school on a weekly basis. The plan at this time took six years to complete, since summer sessions were not incorporated. The curriculum was soon shortened into the present five year plan, and the alternate periods of schooling and job education was lengthened from one to two to four, and finally to eight weeks, which is the period now used by the University of Cincinnati. During the first several years of the new engineering plan, Schneider did his own co-ordinating by visiting the students at their jobs, offering suggestions, and finding out how much progress was being made by each student. The newly-formed Co-op Plan had become quite popular in its first year, and by the second year, there were more applications for admission into the plan than the University had vacancies. During the first three years that the plan was in operation, the University of Cincinnati did all the basic groundwork, and soon other schools were adopting the plan. The Co-op system has been continuously expanding since its start at the University of Cincinnati. Today there are 626 Co-op firms located in 125 cities, working in conjunction with some 30 colleges and universities with a total enrollment of 3000 students participating in the plan.

A good example of the Co-op plan may be seen in examining the program followed at Cornell University. It is an example of simplicity and follows the same scheduling of courses as followed by the regular students. The cooperative schedule begins after completion of the second year. As shown in the accompanying table, the cooperative student's schedules are correspondent to the schedules of the regular students.

The Co-op plan at the various participating colleges and universities is open to students who are enrolled in Electrical, Mechanical, Civil and Chemical Engineering. Right now the grade point required of a student wishing to take part in the Co-op plan is set at 3.5 on a 5.0 grading system such as ours (a grade of 75 or better in other systems). One more step is required before the engineering student can take part in the plan: a successful interview with the company representatives. Interviews of this sort are similar to the senior interviews that are going on here on the Illinois campus, the only major difference being that it is only for part-time work.

Students taking part in the plan are required to turn in formal reports at least once during each period of their industrial training, describing their activities and observations made on the job. No credit is given the student for the submission of these reports; however, they must still meet the standards of both the school and the cooperating industry. The Co-op students are also rated by their employers during each industrial period, and must secure a satisfactory rating in order to continue in the plan.

The major advantages of the Co-op plan may be seen in the aims of the Committee on Aims and Ideals of the Co-operative Education Division of the American Society for Engineering Education: "To impart firsthand an actual knowledge of and experience with the execution in industry of engineering designs, projects, and developments. To impart understanding of and familiarity with the problems and the viewpoints of working men and women. To assist students, by direct and personal experience in industry, to test their aptitude for engineering careers. To enable engineering students to adjust themselves to engineering employment by gradual and easy transition from academic pursuits and mode of life to the requirements and conditions of industry. To train and otherwise prepare students especially and directly for administrative and operating functions which, to a greater or lesser degree, enter into most engineering careers."

Thus we have seen that the Co-operative Plan for Engineers is one in which education and industry work hand in hand to achieve an ultimate and common goal: a better engineer. It was Herman Schneider's idea to have sort of engineering education in which to bridge the gap between college and industry, without the usual "breaking-in" period. The Co-op Plan is available to Electrical, Mechanical, Civil, and Chemical Engineering students, and is a plan in which: (1) the curricula of the student leads to a degree of Bachelor of Engineering or both Bachelor's and higher degrees; (2) the student alternates periods of educational learning at college with periods of working knowledge gained by employment in industry; (3) the employment periods are considered as part of the engineering student's essential education; (4) the employment of the engineering student shall be of such so as to pertain to his field of study; (5) the employment is to be variegated, so as to offer the "Co-op" a broad as possible amount if experience; (6) the minimum hours of employment are specified as requirements for a degree.

FARMING FORESTS and FASHIONING FIBERS

ALLIED FOR CREATIVE RESEARCH
The seven major Divisions of Allied Chemical offer rewarding careers in many different areas of chemical research and development.

A low-flying plane spreads ARCADIAN fertilizer on forest land and — for the first time — a new technique is available for making a vital crop grow faster.

That smart coat — fashioned of exciting CAPROLAN *deep-dye* nylon — seems remote indeed from growing trees. But both these new concepts in fibers and forestry depend upon Allied's creative use of nitrogen. Together they spell chemical diversity.

HERE'S HOW THEY'RE

ALLIED

Some of Allied Chemical's 3000 products for farm, home and factory are described in a new booklet, "Introducing Allied Chemical." Write for a copy.

TRADEMARK PRODUCTS INCLUDE:

Arcadian fertilizers • Caprolan nylon • Plaskon resins • Mutual chromic acid
Genetron aerosol propellants • Wilputte coke ovens • Solvay chloromethanes

Allied Chemical

61 BROADWAY, NEW YORK 6, N. Y

THE SOCIETY COLUMN

by Don Snedeker, E. E. '58

Last month the names and addresses of several society presidents were omitted. The reason was in part, shall we say, a typographical error and in part the fact that we were unable to obtain certain ones at that time. In any event, we now have this information and for those interested, it is herewith listed:

Pi Tau Sigma
John Young, 410 S. Busey, U.

Sigma Gamma Tau
Donald Vanwinkle, 1109 W. Springfield, U.

Physics Society
(Temporarily dicontinued)

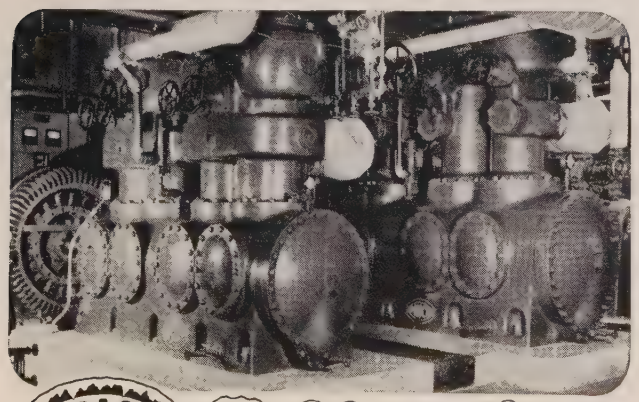
BEST IDEA OF THE MONTH comes to us from the Engineering Council concerning a "coffee break" for engineers. Bill Mavity, junior in EE, is chairman of the committee investigating the possibilities of such an event. He tells us that the major thought is to have something like one hour a week where engineers may gather with the deans and other key members of the engineering faculty.

At times, the "coffee break" may be an informal round-table discussion on "The Engineer and the Draft," or "The Engineer and the Humanities." At other times it might consist of a lecture followed by a question and answer period on some subject such as "Technical Speaking" or "Proper Techniques of Report Writing for Effective Presentation." Then again, we might merely roam around the room with our coffee and become better acquainted with our college and curriculum deans; and we might shake hands with such noted members of the faculty as Professor John Bardeen, Nobel Prize winner for his work on transistors. The "coffee break" sounds like something we engineers have needed for a long time and its hould become a reality in the near future, possibly by the time this column goes into print.

MOST NOTEWORTHY DISCUSSION OF THE MONTH took place at the University YMCA on November 13. The subject was "The Future of Electrical Engineering in Industry," and the scene was the annual dinner meeting held by the AIEE-IRE. Approximately one hundred student members of AIEE-IRE joined fifty members and guests from the Central Section of the AIEE to enjoy dinner and hear the discussion by speakers from RCA, IBM, Commonwealth Edison, GE, and McDonnell Aircraft. The meeting was rather long, but quite worth the expenditure of time.

A Side-Note heard to the amusement of some was, "Why worry—electricity will never be practical anyway!"

SOMETHING TO THINK ABOUT: Engineering Open House is not too far away! Each and every one of us should be planning a display or project to help make it a big success again this year. Open House is something that the engineers of the University of Illinois are justly proud of as an opportunity to exhibit their knowledge and the wonders of science to the rest of the campus and visitors from all over. The theme this year is "What is an engineer?" This can be very thought provoking.



FRICK Refrigeration

Serves Big Esskay Plant in Baltimore

The Wm. Schluderberg-T. J. Kurdle Company operates the largest meat packing plant on the East Coast. Their Esskay brand products are recognized as top quality.

The refrigerating system at the Baltimore plant has lately been expanded with additional Frick equipment. This includes three large compressors, operating in two stages; liquid ammonia pumps; and 18,400 feet of galvanized square-finned pipe. Results have been more than satisfactory.

Get data now on Frick Graduate Training Course in refrigeration.

FRICK COMPANY, *Waynesboro, Penna.*

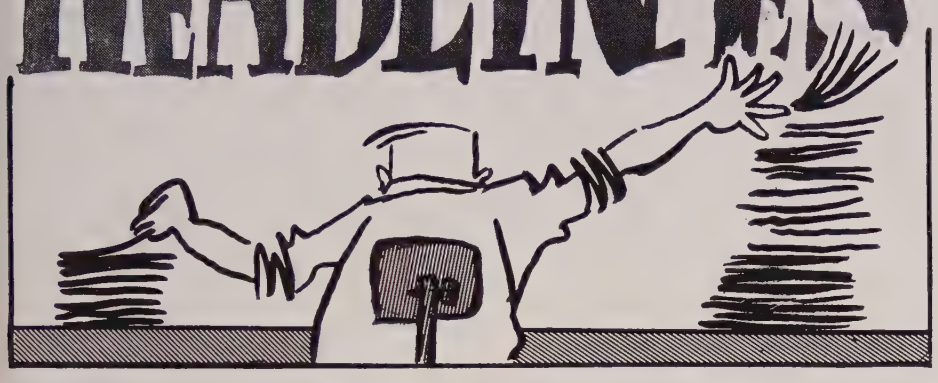
Help Wanted!

The Technograph needs men and women interested in gaining experience in:

- **BUSINESS PROCEDURES**
- **WRITING**
- **MAKE-UP**
- **ILLUSTRATIONS**
- **ADVERTISING**
- **PROMOTION**

Apply at:
THE TECHNOGRAPH OFFICE
213 Civil Engineering Hall

SKIMMING INDUSTRIAL HEADLINES



edited by Harry Hirsch, E. E. '57

Tooling Up for '57 Cars

The automotive industry spent over $100 billion for new tools and equipment preliminary to production of the 1957 cars, reports *American Machinist.* General Motors allocated approximately $400 million; Ford Motor Co., $300 million, and Chrysler Corp., $200 million. Current plans call for the manufacture of 6½ to 6¾ million new cars during the coming year.

Progress in Welded Highway Bridges

A recent survey of state bridge departments, made by The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, has revealed an increasing trend towards the use of welded bridges in the country's rapidly expanding highway system. Of the 39 state bridge departments responding to the survey, 15, or 38%, were using an increased number of welded highway bridges. Another 13 states or a total of 72% were using welding for certain details such as coverplates, diaphrams, shoes, etc. Many of these states were considering adopting completely welded designs for more of their bridges.

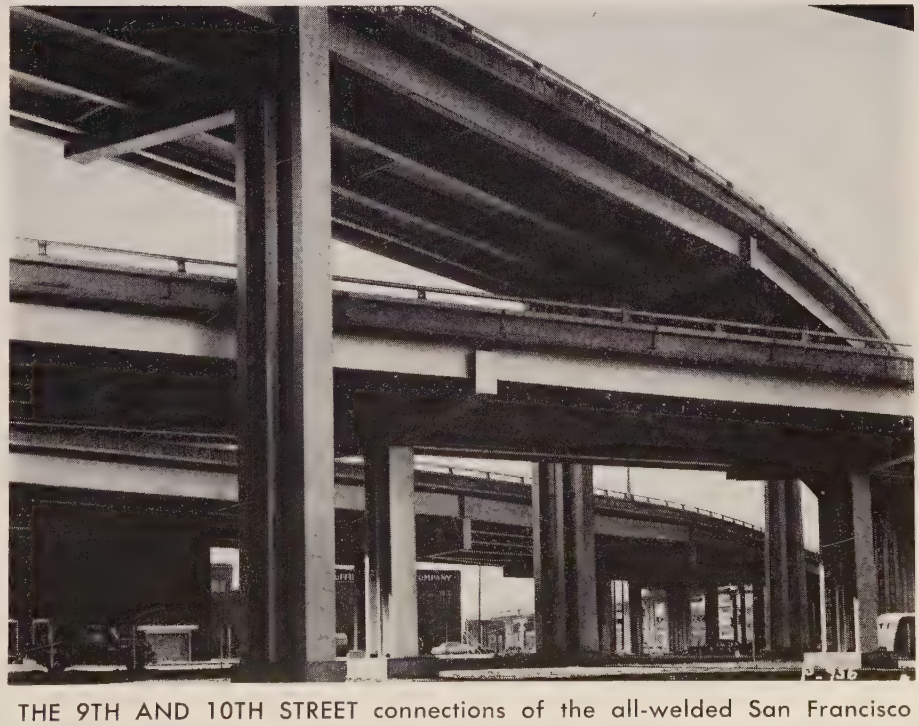
Reported savings in steel in typical bridges, resulting from welded design, ranged up to 20%. If this savings were extended to the long range road building program that has been initiated by the Federal Government, enough steel could be saved to build a typical highway girder bridge approximately 800 miles long. The projected highway program of 51 billion dollars will require an estimated 23 million tons of steel. Approximately half of this will go into bridges and overpasses. If welded design were able to save 20%of this requirement, we would save, on bridges alone, more than three times as much steel as was used for all highway purposes in 1954.

Savings in cost that can be realized on welded bridges have also been reported to amount to 15to 20%.

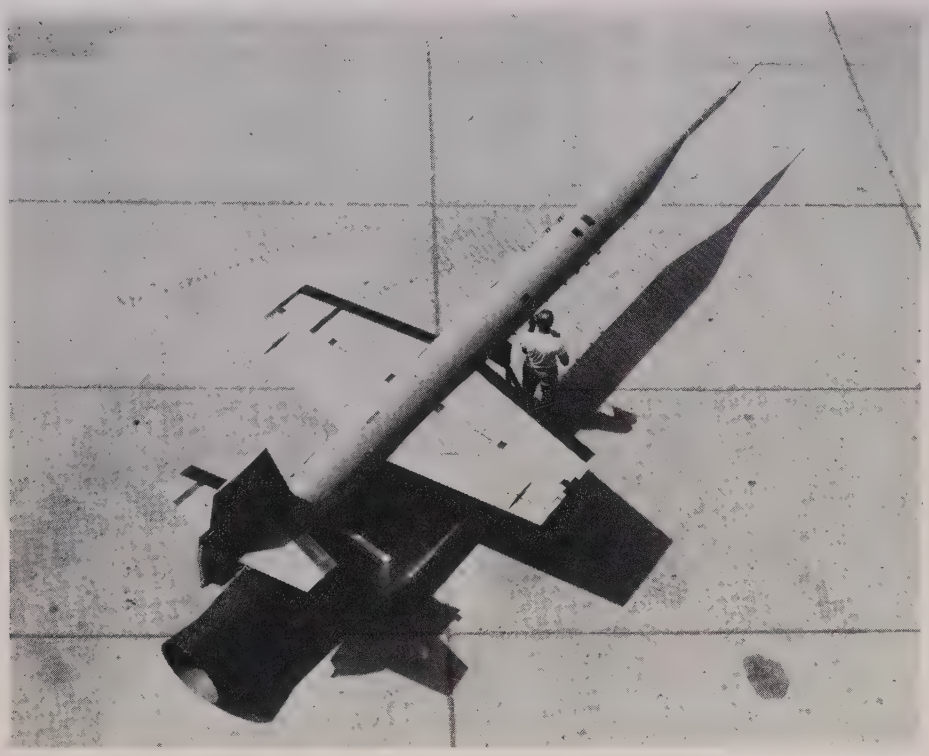
Thus savings in both material and cost through welded design afford a tangible assistance in developing this road program to the fullest extent possible with the available material resources and funds.

Birds vs. Hi-Fi

Birds nesting on the edges of airport runways have caused a number of jet plane accidents by being sucked into the jets' air intake, reports *American Machinist.* The cure, or so it was thought: a high power, ultrasonic generator mounted on a truck that was driven down the runways. It was believed that the sound would scare away the birds. After their initial surprise, however, the birds took no notice of the noise. But the experiment wasn't wasted; it was discovered that the sound waves possessed unusual ability to snuff out fires when bounced off a wall or other surfaces. Such sound trucks may be used in the protection of oil tank fields from fire.



THE 9TH AND 10TH STREET connections of the all-welded San Francisco Freeway Viaduct. This is the world's largest all-welded structure in terms of tonnage. Spans range up to 170 feet. (Photo credits James Lincoln Arc Welding Foundation, Cleveland, Ohio)



SUPERSONIC LOCKHEED X-7 built by Lockheed's Missile Systems division. It flashes through the stratosphere under ramjet power at speeds well beyond the velocity of sound.

Boneyard Facelifting

The Boneyard, may get a face-lifting as a result of the construction of a superhighway north of here. The stream lies in the path of the improvements underway on U.S. Highway 150 and must be relocated for at least 2100 feet.

Additional improvements to the highway will mean more runoff into the creek and the Boneyard, source of countless jokes throughout the 88 years of the University's existence will be overtaxed by the additional flow, says Edward M. Anderson, engineer.

The new superhighway will link Danville and Rock Island and also connect with similar highways in Indiana and Ohio. Bids for paving are being sought and the highway is expected to be completed between Danville and Champaign by summer, 1957.

College Reactors

Design of a miniaturized low cost atomic energy reactor small enough to fit into any school, industrial, or medical laboratory was announced today by Atomics International, a division of North American Aviation, Inc.

The compact "Laboratory Reactor" is contained in a tank only eight feet high and eight feet in diameter, and can be installed in any existing laboratory building without the addition of any special facilities.

Priced at $55,000 the Laboratory Reactor can be constructed, installed and ready-to-run at any location in less than six months.

Designed specifically for small laboratories, the reactor will permit a wide range of research and training in the nuclear field. Operating at a power level of only five watts, the reactor will provide sufficient radiation for important studies in the engineering, biological and medical fields.

The "core" of the reactor, where atomic fission takes place, is a one foot stainless steel sphere containing about four gallons of enriched uranyl sulfate in a water solution. This core, surrounded by a six-inch thick lead shield, is housed in an eight foot tank with ordinary water. A number of exposure facilities and beam tubes are provided to permit several experiments to be carried on while the reactor is operating.

Only one operator is required to run the reactor which is controlled by a single console panel.

"The availability of this safe simplified low cost reactor will open the door to widespread study in the development in the nuclear field," according to Dr. A. B. Martin, Director of Technical Sales for Atomics International. "The Laboratory Reactor is expected to do for the nuclear science field what the Model T did for the automobile industry," Dr. Martin said.

New Test Plane

A supersonic Lockheed test vehicle, which has played a major role in the development of powerful new engines for Air Research and Development Command ramjet missiles, has been disclosed. It is the X-7, designed and built by Lockheed's Missile Systems division.

Details of the needle-nosed vehicle were revealed by Brig. Gen. Marvin C. Demler, deputy commander for research and development of the Air Force's Air Research and Development Command, in an address to the Air Force Association in New Orleans.

Although exact performance is classified, it was revealed after several years of secrecy that the X-7 flashes through the stratoshere in level flight at speeds well beyond the velocity of sound.

"In our ramjet development program," General Demler said, "we have used the X-7 as a high speed test bed to get test and design information in actual flight. Through this research and testing program, we are developing successful ramjets for operational use.

"Also," Demler added, "this supersonic vehicle has served as a test bed for the development of other important missile components."

According to Lockheed's missile scientists, the X-7, while not the first to use ramjet engines, is making important contributions to the development of the ramjet principle as a dependable new source of missile power.

Ramjets, considered the ultimate in ducted-jet engines for guided missiles, are comparatively simple devices that give tremendous power at high speeds. Unlike conventional jet engines, the "flying stovepipes" have no compressors or other moving parts an ddepend upon their own high speed to compress their air intake. Generally speaking, the faster they go the better they operate—without the limiting factors, such as compressor speeds and heat, that limit conventional jets.

Much of the electronic gear carried by the X-7 and related data reduction equipment to decode flight information was developed by Lockheed scientists. The X-7 is being built at Lockheed's Missiles Systems division, Van Nuys, Calif. The ramjet engine mounted on the X-7 was developed by Marquardt.

In describing the operation of the X-7, General Demler told an Air Force Association audience that the test vehicle is taken aloft by a B-29 and then launched.

"A rocket booster drives it up to the speed where the ramjet operates efficiently and takes over to accelerate the vehicle," Demler declared. "The supersonic vehicles are recovered by parachute and will be used again for future test flights.

"This," Demler stressed, "represents quite a savings in our testing program."

AS THE PROCESSED microfilm leaves the drying cabinet, it is inspected with a magnifying glass to check for surface scratches.

Microfilm "Windows"

Microfilm "windows" in tabulating cards, used for transmitting engineering drawings are expected to save upwards of half a million dollars annually in the Army Signal Corps procurement program, it was revealed here today by Maj. Gen. J. D. O'Connell, Chief Signal Officer, Department of Army.

One of the special machines used to mount the microfilm images of drawings in windows known as apertures in punched cards was demonstrated to the public for the first time here today at the second annual exhibit of latest innovations in Army operating methods and equipment.

At Ft. Monmouth, New Jersey, over 300,000 engineering drawings have been microfilmed. Positive film prints, made from the original microfilm negatives, are being mounted in tabulating aperture cards. They will be distributed to various Signal Corps installations throughout the world for reference in the repair and overhaul of Signal equipment and for procurement purposes.

They will also be used to make reduced-size paper prints to use for issuing bids to industry. The new system replaces the old costly method of making full-size paper reproductions of drawings.

"In previous national emergencies, the procurement of new equipment for military communications was seriously handicapped by the delay in reproducing engineering drawings and getting the bids out to manufacturers," General O'Connell explained.

"The new microfilm-aperture card system," he added, "will provide us with the means of cutting days and weeks off the time of getting contracts underway for new military projects essential to our defense.

"At the same time, the aperture cards will keep repair depots up-to-date on all changes in the drawings of existing equipment. Where depots formerly had to get full-size drawings from a central source, they can now produce the necessary copies from the microfilm images on the spot."

Most Signal Corps drawings, some dating from World War I, have been converted to microfilm images the size of a match pad.

Seven Recordak microfilm machines were used to photograph the drawings, reducing them in size by 16 and 29 diameters. Positive film prints were produced and mounted in Filmsort aperture cards to get the necessary copies for the various installations. About five million cards will be needed to provide all the necessary duplicate sets of cards.

At present, new drawings and changes in old ones, average about 500 a week. These will be microfilmed and duplicate positive prints in aperture cards provided to installations on a regular monthly basis.

$5,000 for Engineering Undergraduate Designs

The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, has announced the 10th in its series of design competitions for college engineering undergraduates. The Foundation is offering $5,000 in cash awards to students and scholarship funds to schools for undergraduate mechanical or structural designs in which arc welding is used. Actually two separate competitions are offered, one in mechanical and one in structural designs. A total of 46 awards will be made, the highest being $1,250. Winners and their schools also receive national professional recognition.

Any resident college engineering undergraduate may compete by entering a design for a machine, machine part, structural or structural part which makes a significant use of arc welding. Rules booklets are available free from The James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio.

UI Hip Roofs

Hip roofs can now be built with nail-glued trusstes. A design for such a truss system has just been released by the University of Illinois Small Homes Council.

The truss, which is for a 3-in-12 inch slope, is the newest of the Council's truss designs utilizing the nail-glued technique developed by the Council and Purdue University.

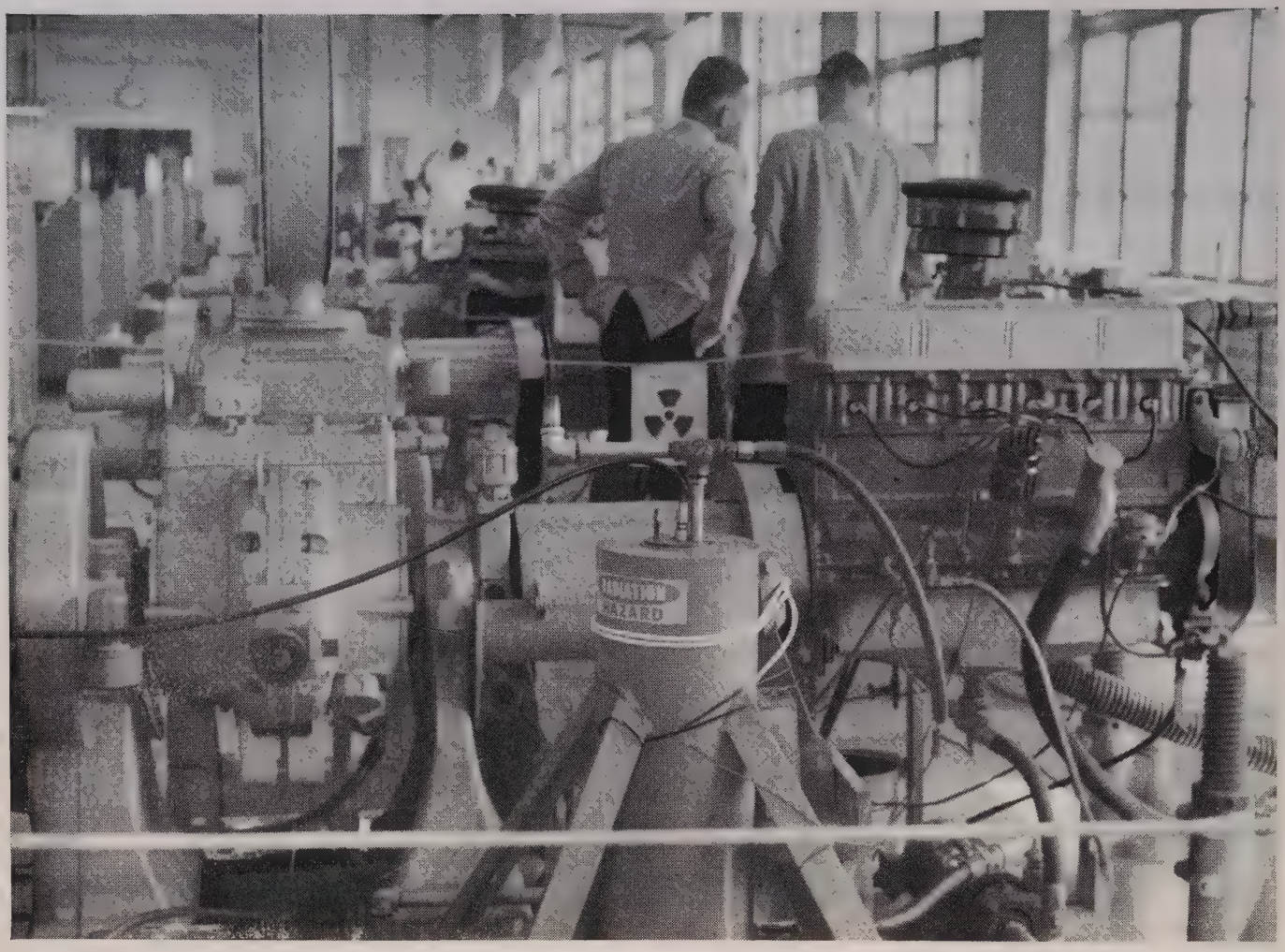
Directions for building the trusses for spans of 21 feet to 28 feet 8 inches are presented in an instruction sheet prepared by Howard E. McCall and Prof. James T. Lendrum, architects, on the Small Homes Council staff.

The instruction sheet, which shows the geometry of the trusses and complete details for assembling them, is available for 25 cents from the Small Homes Council, Mumford House, University of Illinois, Urbana.

Hip roofs are popular because they make a house look low, but they are difficult to build by conventional roof-framing methods and they require experienced carpenters. Up until now, trusses have seldom been used for this type of roof.

The University of Illinois truss system uses flat-top trusses, which are spaced 2 feet on center. A terminal truss supports and jack rafters used in conventional hip-roof construction are eliminated.

The trusses have been tested not only in the laboratory but also under long-term load and in the field by a builder.



Modern and advanced engines log up hundreds of test hours daily in Standard's automotive laboratory at Whiting. Radioactive carbon traces deposits in the guarded engine (foreground).

Would you like to work on the same team as this man?

LAMONT ELTINGE is a group leader in the Automotive Research Division of Standard Oil's great Research and Engineering Laboratories at Whiting, Indiana. He and his group dig freely and fruitfully into just about every area you can think of in diesel, automotive, gas turbine, and jet fuels. Current studies range from air pollution problems arising from diesel smoke to laboratory use of radioactive carbon tracers for the basic study of deposits in gasoline engines.

Mr. Eltinge earned his B.S. in mechanical engineering at Purdue in 1947. He is a member of SAE, Tau Beta Pi, Sigma Tau, and Pi Tau Sigma. Along with the important contributions he makes to Standard as a regular member of our team, he finds time to attend Illinois Institute of Technology where he recently received his M.S., and takes an active interest in church work.

Lamont Eltinge and hundreds of young men like him are going places and doing things at Standard Oil. Each concentrates on his own special field of interest and experience, but none is limited to it. Chemists, metallurgists, engineers, physicists and others maintain a continuous relationship for the broad exchange of ideas. Perhaps you, too, would enjoy membership on Standard's team of engineers and scientists.

Standard Oil Company

910 South Michigan Avenue, Chicago, 80 Illinois

STANDARD

AIR CONDITIONING:

Engineers make it a LIFE-TIME Career at York

- **Expanding markets in air conditioning, refrigeration are creating new opportunities for engineers.**
- **York Training is a recognized pathway to professional development.**
- **York's products and applications are precision-engineered for every mechanical cooling need.**
- **Resulting career choices call for engineering graduates with widely varying talents and interests.**

Today, air conditioning is much more than a luxury or convenience. For many industries, businesses, and even residences, it is more than necessary—it's expected. The same is true in precision refrigeration. Both spotlight the unprecedented needs for expertly trained engineers to design, manufacture, apply, and maintain such systems for widely varying needs.

York systems are engineered. The company's reputation comes from its demand that the *system be tailored to the need.* The YORK engineer has at his disposal both the know-how and the facilities to produce and apply more air conditioning and refrigeration system components than any other manufacturer in the industry. Thus, the YORK engineer can give full play to his own creativeness in serving the Industrial, Commercial, and Residential markets. At York, the jobs vary. Today's might be a hotel, tomorrow's a shopping center or an environmental laboratory.

How do engineers get ahead at York? Of the 25 top engineering executives at York, *19* came up through the YORK Graduate Engineer Training Program. This program blends classroom and on-the-job assignments into *personalized* plans of post-graduate education directed to the specified placement chosen.

Exchange information about yourself and a YORK career at your College Placement Office. There you'll find the booklet "A Pathway to Professional Development and Life-time Careers". Register there for a campus interview with York's representative. Mail inquiries will receive careful attention. Write: Training and Education Department, York Corporation, a Subsidiary of Borg-Warner Corporation, York, Pennsylvania.

York refrigeration air conditioning ®

the quality name in air conditioning and refrigeration

YORK BW

HEADQUARTERS FOR MECHANICAL COOLING SINCE 1885

YORK CORPORATION

SUBSIDIARY OF BORG-WARNER CORPORATION

Engineer's Criteria for Dates

(Notice—All units will be designated in MKS units. If necessary use the constants given here.

$e_o = 8.85 \times 10^{-12}$ coul. ^{2}/ nt. m.^{2}
$g = 9.80$ kg. m./sec.^{2}
M.P. of Tungsten = 3673 K°

Simple questions requiring only a yes or no answer will be answered with a simple yes or no answer. (If you want a good rating, answer yes.)

What is the linear distance from the top of your head to energy potential zero? .....

What is your mass times gravity? .....

Do you consume ethyl alcohol (C_2H_5OH) in various mixtures? .....

Do you absorb collodial suspensions containing harmful nicotine and tars? .....

List the various ingenious methods in which you have applied Gauss' law to electrostatic conditions.

.....

.....

.....

.....

Do you have a slide rule? .....

How complicated? ..... (That is not clear, explain!) .....

.....

On a separate ream of paper write a thesis on vector analysis. (7×10^{13} words)

Have you ever had your finger caught in a paper stapler? .....

How'd you do it? .....

Is your finger free of the staple now? .....

State what you think is the most interesting part of integral calculus. .....

.....

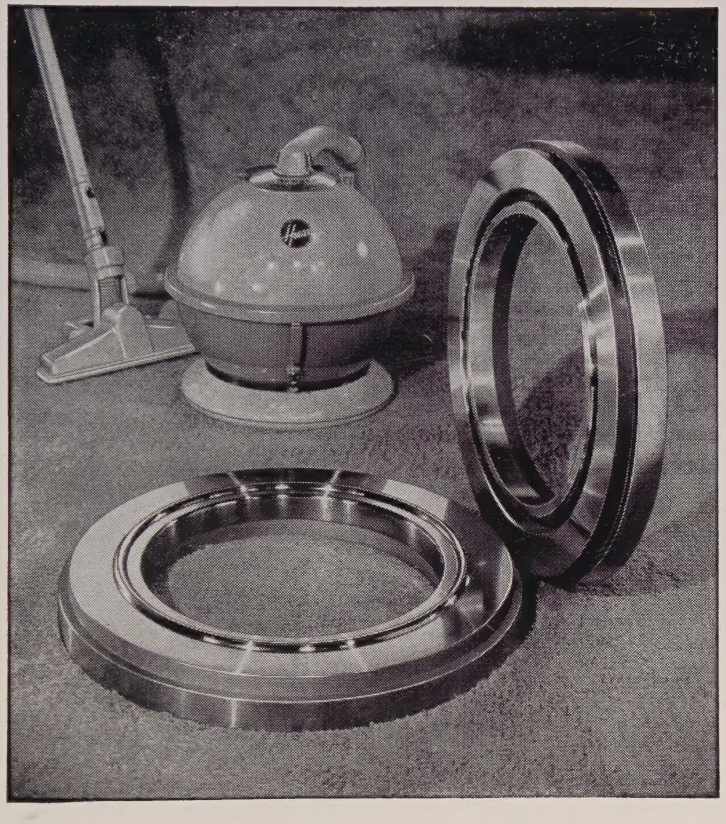
Do you think that Descartes was a greater mathematician or philospher? .....

Have you yet realized that money isn't everything? .....

PROBLEM: If a B-52 flying at 500 MPH. at 50 Km. hits a hawk in the side, and is driven off its course by an angle x (x= .003 radians) into a green snowstorm over Washington, D. C. while the president's inaugural address is being given, what size shoes does the hawk wear? (Give both length and width.) ....., ...

Another page for **YOUR STEEL NOTEBOOK**

How to shape a vacuum cleaner like a basketball

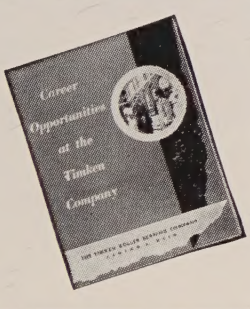


TO make their new vacuum cleaner functional as well as handsome, engineers at the Hoover Company developed a nearly round design. The problem was how to produce it economically.

The first ring dies they used to produce the shape from sheet steel picked up bits of steel and scored following pieces. Production had to be shut down while the dies were polished. Finishing costs ran high.

After studying the problem, Timken Company metallurgists recommended a special analysis of tool steel for the dies. Graph-Mo®, developed by the Timken Company. Minute particles of graphite in Graph-Mo act as a built-in lubricant—keep parts from galling. Diamond-hard carbides in its structure make it wear, give it longer life.

With the new Graph-Mo dies, downtime was cut 50%. Production rolled smoothly. The dies outlasted previous ones 3 to 1. It's another example of how Timken pioneering in fine alloy steels helps solve knotty industrial problems.



Want to learn more about steel or job opportunities?

For help in learning more about steel, write for your free copy of "The Story of Timken Alloy Steel Quality". And for more about jobs at the Timken Company, send for a copy of "Career Opportunities at the Timken Company". Address: The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

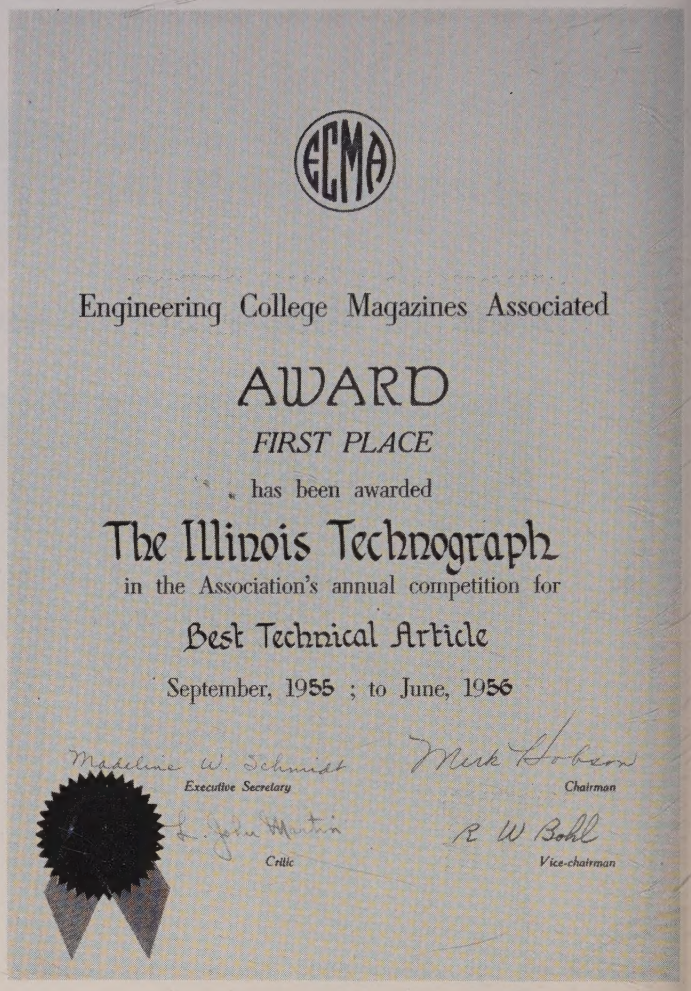
TECHNOCLIPS

Early in November, four *Technograph* staff members, Editor Harry Hirsch, Business Manager Don Georgi, Roger Harrison, Jim Kries and *Technograph* adviser, Prof. Robert Bohl, traveled to Fayetteville, Ark., to the University of Arkansas campus for the annual Engineering College Magazine Assn. meeting. This annual convention serves as a gathering place for the staffs of the 45-odd magazines which make up ECMA. Here, we slate our policy concerning editorial material, advertising and other related functions for the next year. We elect a chairman to preside and handle all material pertinent to the organization during the year. And, dear to the hearts of all member magazines, we give awards for outstanding work in the field of writing, photography, layout, best magazine, etc.

Technograph came out rather well, we thought, Prof. Bohl was elected chairman of ECMA. He had previously served as vice-chairman. *Technograph* won an honorable mention and first place award for technical writing. First place was won by Circulation Manager Phil Philhower's article on "Flight and the Heat Barrier," which appeared in our May, 1956 issue. Naturally we are proud of Phil and of ourselves for these awards. They serve as a stimulus for great things. Not only the idea of awards, but for a better magazine, which cannot be measured on an awards basis.

Why, you may ask? The reason is because each magazine has its own audience and thus its own goals. We have a large high school audience as well as a college audience. Thus in a sense, we must cater to both.

Technograph not only tries to inform, entertain and enlighten college engineers as to what is happening in the field, both on campus and in the "great outside world," but it serves as a means of doing to same to high school students who are interested in entering the field of engineering, but not sure exactly what to expect. We try to make everybody happy, but if we don't we have nobody to blame but ourselves.



However, being a small group, we can't possibly extend ourselves to all parts of campus, much less all parts of the state of Illinois or the nation. That's why we are asking your help. If you think something needs improving in *Technograph*, something must be dropped, something is lacking or have an idea you wish us to write about, please fill out the tearsheet at the bottom and send it to us. We shall try to act on your proposals and we shall print the more interesting of them.

This column, "Technoclips," is one means of getting a better liason between us and our readers. Here we propose to enclose informal notes about what makes *Technograph* click. That is, why do we write what we write, how do we write it, and who writes it?

You may have turned to this page expecting to find "Technocracks," our joke page. Well "Technocracks" has gone the way of all flesh. Finding the same jokes repeated over and over again, some corny and some slightly shady meanings, we have decided to drop that little page. However, this doesn't mean we are going to adapt a sobersides attitude. We shall print as often as we can, cartoons, features and other material that shows the lighter side of engineering and reflects original thought rather than perusal of worn-out joke books or "Playboy."

One other short note. Last month, avid readers may have missed the presence of our "Technocutie." Due to publishing deadlines, our little miss was among the missing. However, the absence was only shortlived as she returns this month, as big as life as ever, and as ever, happy in her engineering environment.

Illinois Technograph
620 E. John St.
Champaign, Ill.

Dear Tech Staff:

I have the following comments to make on your magazine:

I would suggest the following as a means of improving your magazine:

(Additional remarks, not contained on this sheet, will be welcomed.)